MODERN METHODS OF AMPUTATION

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OF
AMPUTATION

BY
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ONE HUNDRED TWENTY-FIVE ILLUSTRATIONS

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PREFACE

In this monograph the author has intended to include only those methods that are practical and workable. In doing this he has attempted to be brief and concise. It is hoped that he has presented the subject in a manner that will aid in standardizing amputation technic and give to the surgeon, and especially the occasional operator, methods that are simple and direct which afford good functional results.

Many amputations give good operative results that do not give good functional results. Emphasis is here placed upon function, the watchword of all surgical procedures. Amputations deserve as careful technic as other major operations and by such treatment only can stumps be made which may be satisfactorily fitted with useful artificial prostheses.

The history of amputations is not considered. It has also not seemed desirable to include many of the methods that have for years been handed down in amputation literature and have become almost classical.

The chapters on cinematiplastic amputations and artificial limb fitting present the subjects but briefly. The former is still in the experimental stage and to discuss the latter fully would require a volume in itself. The reader is referred to works on artificial limb fitting by E. Muirhead Little, Broca and Ducroquet and the German "Ersatzglieder und Arbeitshilfen."

If this book aids in the simplification of amputation technic, stimulates a realization of the importance of careful surgery, helps to keep function foremost in the mind of the surgeon and leads to a realization that the job is not finished until the patient is fitted, if possible, with an arti-

ficial appliance, it will have accomplished what the author has intended.

Acknowledgment is gratefully made to Dr. C. B. Francisco, Associate Professor of Orthopedic Surgery, University of Kansas, for his helpful advice and criticism of this monograph. I am also much indebted to Tom Jones, Miss Ella Jack and Mrs. Gertrude Schwarz for the drawings and careful preparation of photographs.

T. G. O.

Kansas City, Mo.

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MODERN METHODS OF AMPUTATION

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CHAPTER I

GENERAL CONSIDERATIONS

Indications for Amputation.—In general it may be said that amputation is indicated when an extremity or part of an extremity is useless or harmful to life. There are exceptions to this rule which may be quite evident. The condition of the patient may be too serious to warrant any surgery or the useless part may not be of sufficient importance to make its removal desirable. In such surgery the age and economic condition of the patient must be taken into consideration. The field of indications may be covered very largely by disturbances of circulation, new growths, deformities, infection and trauma.

Preparation of Patient.—The general and local preparation of the patient for operation should not differ from that used in other major surgery. The general condition of the patient must be studied to estimate his operability. This is especially true in emergency cases where shock is a factor and where a little too much surgery might result in death. Some operators have been too prone to amputate at once in traumatic conditions, when a few hours rest and preoperative treatment would be life-saving and would not in any way interfere with a good operative result later. Often a complete operation is attempted when an incomplete would be more in keeping with the vitality of the patient.

In infected or ulcerated parts when immediate operation is not indicated special attention should be given to re-

ducing infection before surgery is instituted. This will always minimize the danger of spreading infection and often permit the saving of more bone and thus make a more serviceable stump.

Skin Flaps.—It is essential that all skin flaps be selected according to available skin and blood supply. There are often times when desirable flaps are not available, and some discretion must be used in making the available tissue fit the part. Often very poorly-shaped flaps, with resultant improperly placed scars, will give very good functional results and are desirable to avoid sacrifice of bone. Ir-

Fig. 1.—Rounded ends of leg stumps made with long anterior and short posterior flaps.

regularities and puckering of flaps should be carefully avoided. This can usually be done by proper study of the tissue present and by applying the well-known principles of plastic surgery. A well-shaped flap usually makes a smooth stump when healed (Fig. 1).

When possible the deep fascia should be included in the flaps. This not only gives them stability, but disturbs the blood supply less than lifting the skin alone.

In the feet and hands plantar and palmar flaps should be used when possible. The skin of the sole and palm is accustomed to weight-bearing and pressure, and will diminish the sensitiveness of the stump when used. In the leg and

thigh long anterior and short posterior flaps are usually desirable (Fig. 54). The functions of the lower extremity are chiefly weight-bearing and locomotion. When a leg or thigh stump is thrust forward in walking the anterior surface of the stump end comes in contact with the artificial limb bucket. For this reason the scar should be placed behind where it will receive the least pressure both from locomotion and bearing. In the arm and forearm, the pressure is greatest laterally and hence it is more desirable that the scar be on the stump end. Anterior and posterior flaps of equal length should then be used (Fig. 19).

Muscle.—One requisite of a good stump is that the severed muscles should receive a new insertion at the stump end. Muscle flaps are usually not necessary or desirable to make good smooth well-shaped stumps. Redundant muscle tissue is likely to produce soft parts which are useless and make the stump more difficult to fit and prone to chafe. If there is any pressure on muscle tissue it will atrophy and is therefore useless as padding. There is no portion of the human skeleton bearing direct weight which is covered with muscle. Muscle is not tissue that will tolerate weight-bearing. It is very important that cut ends of the muscles be grouped about the end of the bone and fixed to the periosteum and fascia so that they will not retract and leave the bone exposed beneath the skin after healing.

Fascia.—This is the strong tissue of the stump and should be used when possible to aid in muscle-grouping and to cover the end of the bone with one or two layers (Fig. 42). Flaps of fascia may be used to advantage in some instances as will be shown later. Fascia flaps sutured snugly over the end of the stump furnish a good tissue for muscle insertion.

Nerves.—Proper care of the nerves is one of the most important features of stump treatment because it is the chief factor in painful stumps. It is usual, after amputation, for most patients to complain that they can feel their toes or

fingers and may for long periods of time complain of a "phantom limb." Neuromata developing on the severed nerve ends are very common and should be avoided when possible at the time of the operation by proper treatment of the end of the cut nerve. In all cases the nerve should be drawn down from between the muscles and divided as high as possible. In addition each nerve of sufficient size to permit should be injected with 95% alcohol (Fig. 40) just proximal to the point of section as recommended by Huber and Lewis.[1] They have proved by experiment that alcohol injection of the nerve end will completely prevent neuroma formation. Hedri[2] recommends cauterization of the nerve ends with the actual cautery. This procedure, he states will cause a degeneration of the nerve fibers upward for a distance of several centimeters.

Blood Vessels.—Careful hemostasis is always a consideration of prime importance. A tourniquet may or may not be used depending upon the wishes of the operator. It is usually advisable except in those cases with advanced arterial disease in which case a tight tourniquet might further damage the vessels. In certain types of amputation, such as disarticulation at the hip, preliminary ligation of the chief vessels should be done. When ligating vessels in the stump as little tissue as possible should be included in the ligatures. Strangulated tissue predisposes to sloughing and infection. All bleeding points should be very carefully ligated to prevent oozing beneath the flaps which might interfere with healing. Secondary hemorrhage in infected stumps may occur several days after operation and prove to be quite serious. This complication should be kept in mind and the nurses and assistants warned of the possibility.

Bone.—Treatment of the bone varies to some extent depending upon the location of the amputation. Most authors

[1]Huber, G. C., and Lewis, Dean: Arch. of Surgery, i, 85, 1920.
[2]Hedri, A.: Arch. f. Klin. Chir., 118, 253, 1921.

agree that the periosteum should be removed from the end of the divided bone for a distance of ½ to 1 cm. (¼ to ½ in.). This is the aperiosteal method of Bunge (Fig. 39). The removal is best done by first encircling the bone with a knife and then thoroughly scraping the periosteum away with an ordinary bone curette. This may be done either before or after the section of the bone. It is not good judgment to cover the end of an amputated bone with the periosteum since periosteum is one of the very sensitive tissues of bone, and redundant periosteum is apt to result in bony outgrowths. All rough portions of the bone should be removed with the saw, file or rongeur. A small quantity of the medulla should be curetted out. Bone bleeding may be controlled by sterile bone wax, or better by instrument pressure.

Drainage.—Most stumps should be drained for thirty-six to forty-eight hours after operation to aid in the removal of blood and serum that may collect beneath the flaps. If there is no infection the drains may be removed at the end of this time. Small rubber tubes with perforations may be used with satisfaction. It is wise to place the drains between stitches and not at the angle of the wound (Fig. 43). A drain between stitches results in smooth healing while a drain at the angle of a wound may produce a dimpling or puckering of the scar. If a stump becomes infected a part or all of the stitches should be removed and good drainage instituted. By proper care of an infected stump, begun early, a reamputation can often be avoided. In connection with the infection, it is to be remembered that a hematoma under pressure beneath a flap may produce fever as high as 103° F., and a leucocytosis, with no discernible infection.

Instruments.—The ordinary instruments used in other operations are used for the soft parts. A rongeur, bone curette, bone forceps, saw and perhaps a rasp file should be added to these. The long catlins and amputating knives, the elaborate tourniquets, Wyeths' pins and multiple saws

are not desirable or necessary. They are relics of the day when extremities were removed in great haste without regard to future function of the stump.

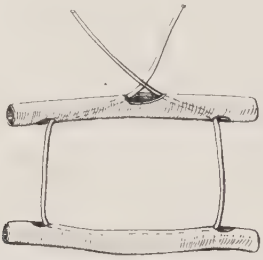


Fig. 2.—Major Chapple's "button suture." This is very useful as a tension suture and available in almost every operating room.

Fig. 3.—Reamputation of leg showing use of Major Chapple's "button suture" to relieve tension.

Fig. 4.—"On end mattress" suture used to prevent turning in of skin edges.

Suture Material.—Plain catgut is usually sufficiently strong to ligate most of the vessels. Chromic gut is advised for the larger arteries, the fascial flaps and for the grouping of muscles. Nonabsorbable material should not be buried in the stump. Sinuses sometimes form from such foreign material and prolong healing and perhaps necessitate another operation. Silk or silkworm gut is preferred in the skin and is usually placed as interrupted stitches. As a tension suture Chapple's "button suture" (Figs. 2 and 3) is satisfactory and easily obtained in any operating room. In closing skin flaps the "on end mattress" suture (Fig. 4) is very valuable to prevent turning in of skin edges.

Dressings.—A snug dressing, not too thick, should be applied to the end of the stump in a manner to equalize the pressure as much as possible. Such a dressing will minimize oozing. In twelve to twenty-four hours the stump is likely to swell and the dressing become very tight. This produces considerable pain and the bandage should be loosened or changed. After returning the patient to bed the position of the stump is important. A stump held in flexion is usually most comfortable and at the same time most likely to produce flexion deformity, which will delay or interfere with proper artificial limb fitting. Splinting, especially at the knee, is sometimes wise to keep the stump in extension. Early, full range of motion of the nearest joint should be urged.

CHAPTER II

AMPUTATION STUMPS

What constitutes a good amputation stump? A good stump is one that is soundly healed, of suitable form and length, painless, well covered with well-nourished skin, without adherent scars or redundant tissue, not bulbous and with the proximal joint capable of normal range of motion.

Scars.—A scar on an amputation stump should be placed in a position where it will receive the least friction. When adherent to a bone a scar may ulcerate easily or become tender when an artificial limb is worn either by direct pressure or by a pulling of the skin due to the motion of the artificial limb socket. The choice of location of scars will be discussed with the individual amputations. A scar that does not interfere with function should usually be left undisturbed. A bursa often forms beneath a scar after a few months' friction, which is nature's effort to promote smooth motion for the scar over the end of the bone.

Tender Stumps.—Tender stumps are due to infection, ulceration, disturbed circulation, neuromata, nerve ends involved in scars, adherent scars subjected to unusual pressure, bone spurs and exposed bone beneath the skin with retracted muscles. Organisms may be latent in the bone or scar which will become actively infectious after trauma. Todd[1] thinks that all neuromata are the result of stump infection. He found that many neuromata showed a chronic neuritis when examined with the microscope.

In the treatment of tender stumps care should be taken to eradicate infection. Neuromata may be treated by excision of the nerve bulb and injection of 95 per cent alcohol into the nerve trunk proximal to the point of nerve section.

[1]Todd, A. H.: Brit. Jour. Surg., 8, 88, July, 1920.

Exposed bone with retracted muscle should be reamputated. Certain ulcers may be very slow in healing and appear to be of the trophic type. Leriche[2] treats such ulcers by periarterial sympathectomy.

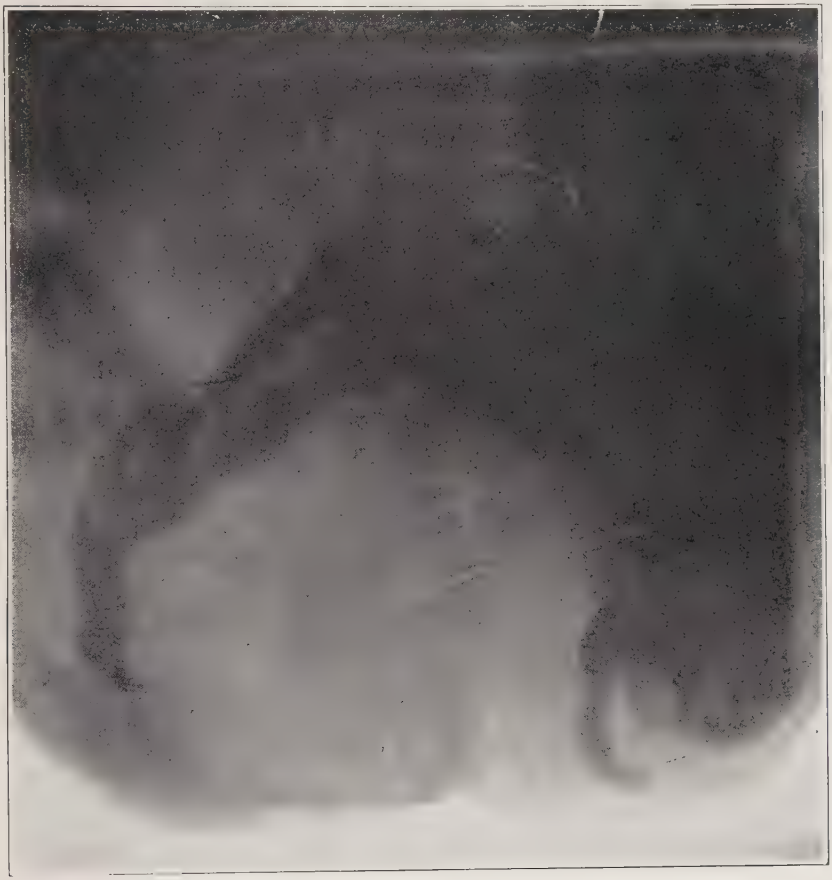
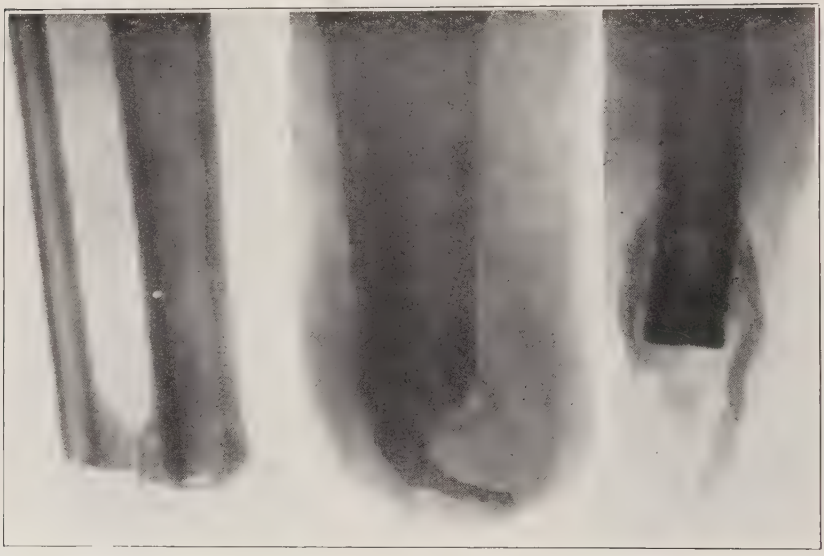


Fig. 5.—Large bone spur in guillotined thigh stump extending into the adductor group of muscles. This probably produced by infection.

Bone Spurs.—Under some conditions spurs are formed, usually extending from the end of the bone (Figs. 5 and 6). These spurs may produce tender stumps by being prominent and receiving pressure from artificial limbs. They are

[2]Leriche, R.: Press Med., 765, Oct. 27, 1920.

caused either by shredding of the periosteum at the time of the operation or by infection. The latter appears to be the chief cause of large spurs. Such spurs are quite frequent in war amputation stumps[3] of the "guillotine" type. Bone spurs are only of importance if they produce symptoms and their mere presence is not an indication for operation. If indicated, an operation should be done and the bone of the stump made smooth.



A. B. C.

Fig. 6.—Bone changes following guillotine amputations. (A) Synostosis between tibia and fibula. (B) Bone spur extending from end of tibia. (C) Bone spurs extending along sinus tracts. The end of the bone has formed a sequestrum.

Contractures.—These deformities are extremely important from the standpoint of fitting artificial limbs. It is obvious that if there is a contracture at the hip (Fig. 7), knee, or ankle (Fig. 8), it will be difficult to fit the patient with a proper weight bearing prothesis. In any amputation the joint nearest the site should be carefully guarded from contractures by proper splinting or motion of active or pas-

[3]Orr, T. G.: Surg. Gyn. and Obst., 30, 195, February, 1920.

Fig. 7.—Contracture at the hip following a high thigh amputation. This may be a troublesome problem in limb fitting.

Fig. 8.—Chopart's amputation showing beginning deformity due to contracture of calf muscles and tilting of scar downward.

sive nature. The shorter the stump the greater the likelihood of contracture. The technic of operation may have some bearing upon the development of these deformities. An abduction deformity at the hip may be due to loss of insertion of the adductors while the gluteus medius and minimus retain their power. At the ankle, contractures may develop by severing the insertions of the flexors with loss of muscle balance. Contractures that have existed for a considerable length of time present a serious problem in treatment (Fig. 9). This is especially true at the hip and knee, where other tissues than the muscles take part in the contractures.

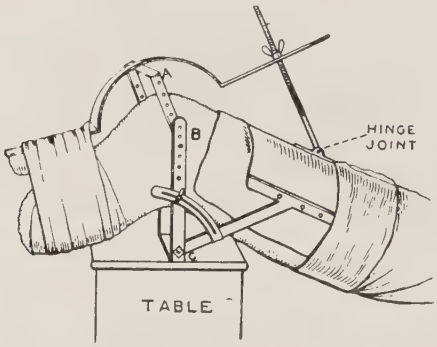


Fig. 9.—The Huggins splint for straightening contractures at the knee joint. Instead of the bandage here shown for sake of clearness plaster of Paris is used to firmly fix the splint to the extremity.

Infection.—This complication of amputation is not uncommon and should be as carefully guarded against in amputations as in other operations. Amputations for infection and those necessary on account of disturbances of circulation are especially prone to infection. An infection may be mild and do little damage or it may be of sufficient extent to ruin what would otherwise be a good stump. It predisposes to tender neuromata, sequestra (Fig. 10), bone spurs, sinuses, adherent scars, sloughing and deformed stumps often requiring reamputation. Drainage, as in all infections, is the essential part of the treatment. Antiseptic irri-

gation, or perhaps better, hot voluminous moist dressings of boric acid or other mild antiseptic, yield excellent results.

Fig. 10.—A typical "ring sequestrum" that so frequently forms after infected guillotined stumps.

Conical Stumps.—These may be the result of a "guillotine" amputation or due to retraction of the soft parts from the bone end (Fig. 11). Such stumps are prone to be tender

and may make satisfactory fitting difficult. However, if healthy movable skin covers the bone, a lateral weight-bearing socket may be worn with comfort.

Jerking Stumps.—Now and then a stump is found which will jump and jerk whenever the patient thinks of it or when it is examined by the surgeon. These usually occur in neurotic individuals and may have very little organic foundation except the amputation. Tender bulbous nerves may be a cause and a cure may be effected by removal of the bulb. When examining some of the jumpy stumps control may be

Fig. 11.—A conical arm stump after a "guillotine" amputation. This stump was soundly healed four years later without reamputation.

obtained by grasping them firmly. These patients can be fitted with artificial limbs.

Skin Extension.—In certain types of stumps in which it is quite necessary to conserve length of bone this can sometimes be done by traction upon the skin (Fig. 12). This type of traction has been used very extensively in the late war in the treatment of the "guillotine" stumps to avoid further shortening. The traction may stretch the skin to some extent but its chief utility is to prevent skin contraction which it very effectively does. It permits healing with less scar. It may be used to remove tension upon stitches when the flaps are sutured so snugly that there is danger

of sloughing. Traction should always be applied to "guillotined" stumps when preservation of stump length is important.

"Guillotined" Stumps.—As a life-saving measure, it is sometimes thought wise to remove a part of an extremity without making any attempt at a finished amputation. The "guillotine amputation" (Fig. 13), which means a deliberate cross-section of an extremity without an effort being made to form flaps has been much used in the late war to preserve stump length and avoid serious infection. It is undoubtedly useful in civil practice in certain severely ill

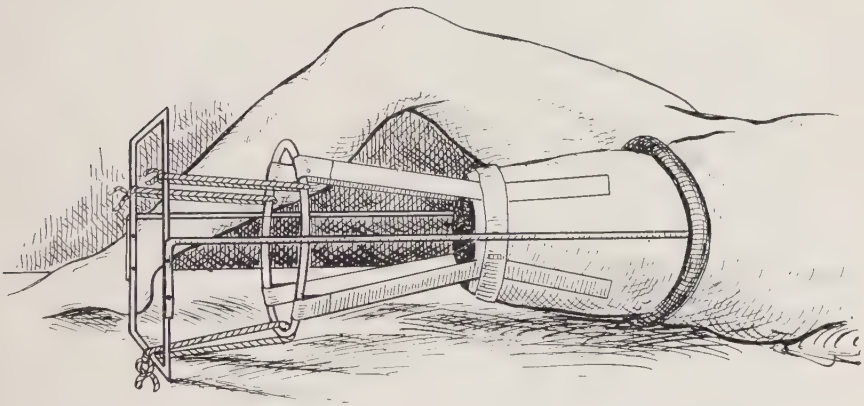
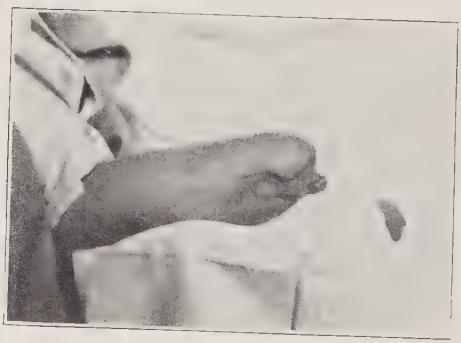


Fig. 12—Method of skin traction with modified Thomas splint. The ordinary Thomas splint may also be used for this purpose. (Military Surgeon.)

patients with infection and in injury cases where speed and minimum trauma are important factors because of shock or potential infection. The "guillotine" may be very advantageously modified by forming skin and fascia flaps and packing them apart or even suturing them back temporarily from the stump end so that they will not interfere with drainage. The "guillotine" may also be done in an oblique manner so that the longer portion may later be utilized as a flap. Practically all "guillotined" stumps are more or less infected. If the infection is extensive, the bone is very likely to show some sequestration. When the periosteum

A.

B.

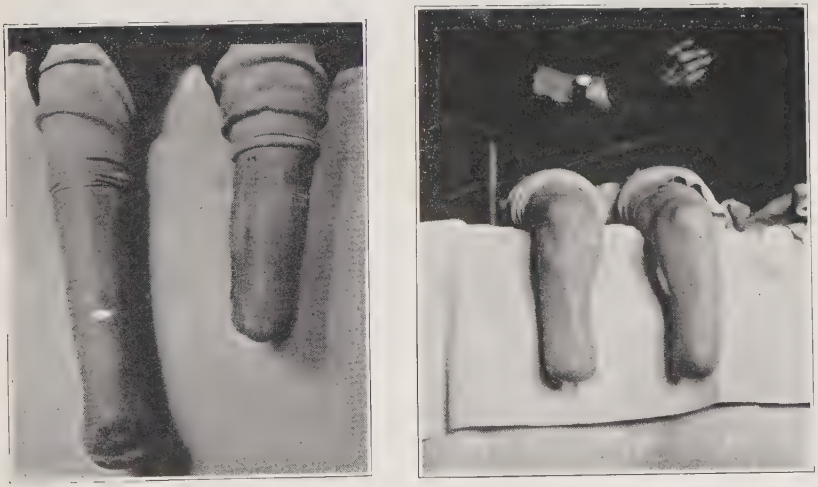


C.

Fig. 13.—Types of "guillotined" stumps. (A) Unhealed thigh stump after six months. (B) Unhealed leg stump with contracture at knee. (C) Oblique guillotine of thigh with protruding bone.

has been removed from the end of the bone at the original operation a circular sequestrum may form which has been called a "ring sequestrum" (Fig. 10). A small percentage

Fig. 14.—Healed "guillotine" of the arm which did not require reamputation.



A. B.

Fig. 15.—(A) A poor Syme and leg stump which is too long. (B) The same after reamputation of both legs, seven inches below the knee.

of "guillotined" stumps will heal with proper skin traction, and make a fairly good functioning stump (Fig. 14).

Operations to Lengthen Stump.—Arm stumps may be lengthened from one-half to one inch by cutting across the

insertion of the pectoralis major. This will permit the pushing upward of the anterior axillary fold giving greater fitting length for the artificial limb. Openshaw[4] has operated to lengthen the forearm stump. By his method the muscles are removed from the condyles of the humerus which, when bulky, push the socket off of a three or four inch stump when the elbow is flexed.

Skin Grafting.—Skin grafts placed upon stump ends are very rarely satisfactory if an artificial appliance is to be worn. These grafts and the accompanying scars do not bear pressure well and soon ulcerate. Pedicle flaps may at times be used with success.

Reamputation of Stumps.— Reamputation is frequently necessary both in military and civil practice. It may be indicated in cases having protruding bone, infection, tender bone spurs, redundant soft parts, further spread of disease, tender or adherent scars and to shorten a stump for better fitting (Fig. 15). If reamputation is done near the stump end, and thus becomes a plastic operation to save as much of stump length as possible, the condition of the stump soft parts must be carefully considered before beginning the operation. It is unwise to operate through infected or edematous tissues. As long as a stump has a firm brawny feel in the area to be cut at operation, it is wiser to treat the condition until the soft parts have softened, which is an indication that infection has subsided. An ulcer on the end of a stump is not a contraindication to a plastic operation. If the evidences of surrounding infection have disappeared the ulcer may be excised and a flap operation done. When removing such an ulcer, it is well to sear its surface with carbolic acid to prevent contamination of the operative field.

[4]Openshaw, T.: Lancet, i, 905, June 16, 1917.

CHAPTER III

AMPUTATIONS OF THE UPPER EXTREMITY

Hand

General Remarks.—Any amputation involving the hand should be considered in its minutest detail before any part is removed. In finger amputations all tissue possible should be saved that has any probability of function. The blood supply to the fingers is good and it is, at times, surprising what tissues will remain viable. A finger may seem crushed beyond the possibility of recovery but still heal and produce a part with function far superior to a short stump. One finger or thumb, if it have good motion, will be much more useful than a complete artificial hand and an apparatus can be fitted in a manner enabling the patient to grasp and pick up objects (Fig. 88).

Technic of Finger Amputation.—Whenever possible in finger amputations a long palmar flap is used. The palmar tissue is better adapted to pressure than the dorsal and will make firmer and less tender stumps. Great care is exercised in finger amputations to make the flap long enough and well fitting. The tendons of the finger are sutured together over the bone end or attached to the periosteum. Careful section of the bone with bone-cutting forceps or small saw will avoid bone splintering and delay in healing. The periosteum is carefully trimmed from the bone and removed for a millimeter or two from the bone end. Such treatment will reduce the sensitiveness of the stump. If a good palmar flap is used it is hardly necessary to attempt to cover the bone end with other tissue since such a flap will furnish sufficient padding. The illustrations show the skin incisions of choice (Figs. 16 and 17). Length of bone should not always be sacrificed to obtain perfect flaps.

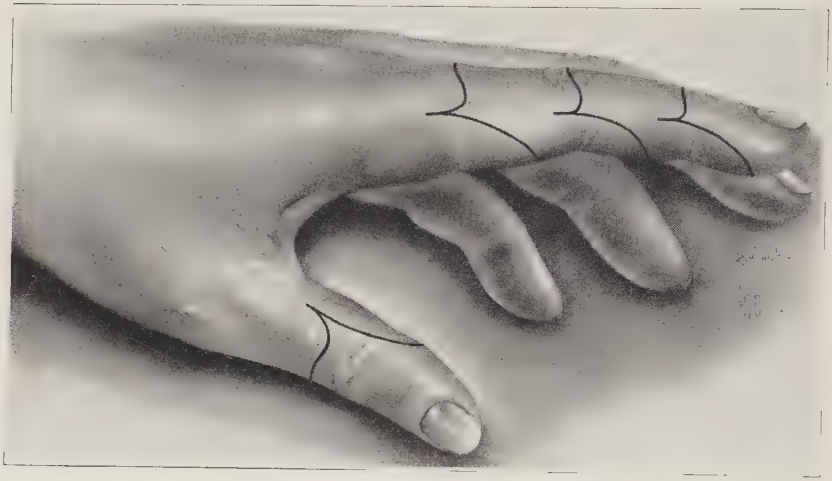


Fig. 16.—Skin incisions in finger amputations.

Fig. 17.—Skin incisions for amputations through the phalanges at or near the metacarpo-phalangeal joints and excision of a metacarpal. See also Fig. 16.

Sometimes what appears to be a very rough piece of surgical work will produce a fairly good functional result. Drainage is usually not necessary unless infection is present. The same technic is used for disarticulations.

Technic of Metacarpal Excision.—A metacarpal bone may be removed through an incision as shown in the illustration (Fig. 17). The incision is made toward the wrist from the finger amputation incision to a point over the carpometacarpal joint. The bone is then removed with as little injury to surrounding structures as possible. Drainage is used if infection exists.

Technic of Amputation through Metacarpals.—At times it may be necessary to amputate across the hand leaving the thumb and perhaps one or more fingers. In such cases a liberal palmar flap is used when possible. The flexor and extensor tendons are sutured together over the bone ends or to the bones to give them a proper insertion to later aid function. The bone ends are made smooth and freed from periosteal tags or shreds. Drainage is used.

Forearm

General Remarks.—As a rule an amputation through the wrist is undesirable (Fig. 18). It is difficult to fit an artificial hand and when it is fitted the apparatus projects beyond the length of the normal hand, producing an awkward appearance. The site of choice in the forearm from the standpoint of fitting is at the junction of the lower and middle thirds. At any point above this to within three inches of the elbow will produce a good stump. Short forearm stumps are difficult to fit because the biceps muscle pushes off the limb bucket when the elbow is flexed. An amputation should not be done through the elbow joint except for temporary purposes. A joint amputation produces a bulbous stump which, if fitted with a joint, makes a wide unsightly arm and requires a laced socket above the bulbous end, which is inconvenient.

Technic of Forearm Amputation.—(Figs. 19, 20, 21, and 22.) A tourniquet may or may not be used depending upon the choice of the operator. When possible anterior and posterior flaps of equal length should be made. It is wise to outline the flaps on the skin before making the incision.

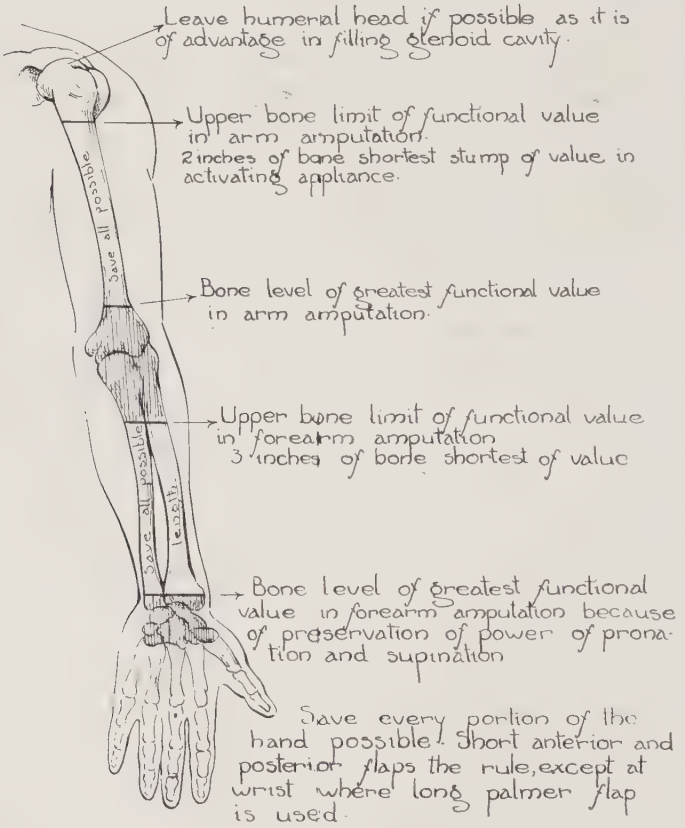

Leave humeral head if possible as it is of advantage in filling glenoid cavity.
Upper bone limit of functional value in arm amputation.
2 inches of bone shortest stump of value in activating appliance.
Save all possible length.
Bone level of greatest functional value in arm amputation.
Upper bone limit of functional value in forearm amputation
3 inches of bone shortest of value
Save all possible length.
Bone level of greatest functional value in forearm amputation because of preservation of power of pronation and supination
Save every portion of the hand possible. Short anterior and posterior flaps the rule, except at wrist where long palmer flap is used.

Fig. 18.—Locations of choice for amputation in the upper extremity. (Military Surgeon.)

The length of the flaps may be determined by measurement, making the sum of the two equal to one and one-half times the diameter of the arm (Fig. 23). Include the deep fascia with the skin flaps. Cut across the muscles at least three centimeters (1¼ inches) below the point selected for divi-

Fig. 19.—Amputation through forearm in the lower third. (A) Skin incisions showing flaps of equal length. (B) Just enough muscle is saved to cover the bone ends. Note that the periosteum is removed from the end of the bone and the marrow scooped out.

Fig. 20.—Closure of the muscle over the bone ends.

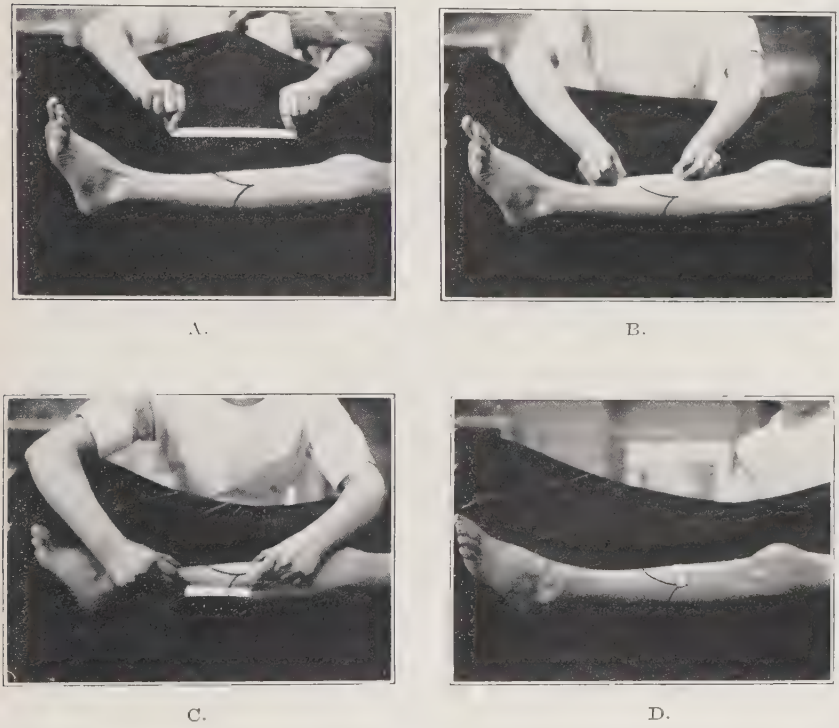
sion of the bone. Remove the periosteum from the cut ends of the bones for a distance of ½ cm. (¼ inch). This is best done by circling the bone with a knife and then using a sharp bone curette to scrape the periosteum downward.

Fig. 21.—The deep fascia is sutured over the muscle completely inclosing it.

Fig. 22.—Skin closure with rubber tube drain.

This may be done either before or after the bones are divided. Remove a small quantity of marrow with the curette. Make the cut edges of the bone smooth with rongeurs or file. Shorten the principle nerves by drawing them down (Fig. 24), injecting high with 95 per cent alcohol,

and dividing just below the injection point. Carefully ligate all bleeding vessels with catgut. Suture muscles or tendons snugly over the ends of the bones with mattress sutures. Do not leave redundant flaps of muscle. Carefully close the deep fascia over the muscle in a separate layer



A. B. C. D.

Fig. 23.—(A) Portion of tape measuring circumference of leg at site of amputation. (B) One half of circumference is approximately one and one-half times the diameter. One-half the length of the tape is here shown divided into thirds to measure anterior flap twice as long as the posterior. (C) Posterior flap measured one-half length of anterior. (D) One-half the circumference of the leg used to measure the width of flaps.

using chromic catgut. Close the skin with interrupted sutures of silkworm-gut. Place a rubber tube drain down to the muscle to be removed in forty-eight hours if no infection develops. Apply a firm but not voluminous dressing.

Arm and Shoulder

General Remarks.—The best arm amputation is immediately above the condyles. At any point above this to within three inches of the joint fitting may be satisfactory (Fig. 18). In amputating higher than three inches from the shoulder joint, it is better to leave the head of the humerus

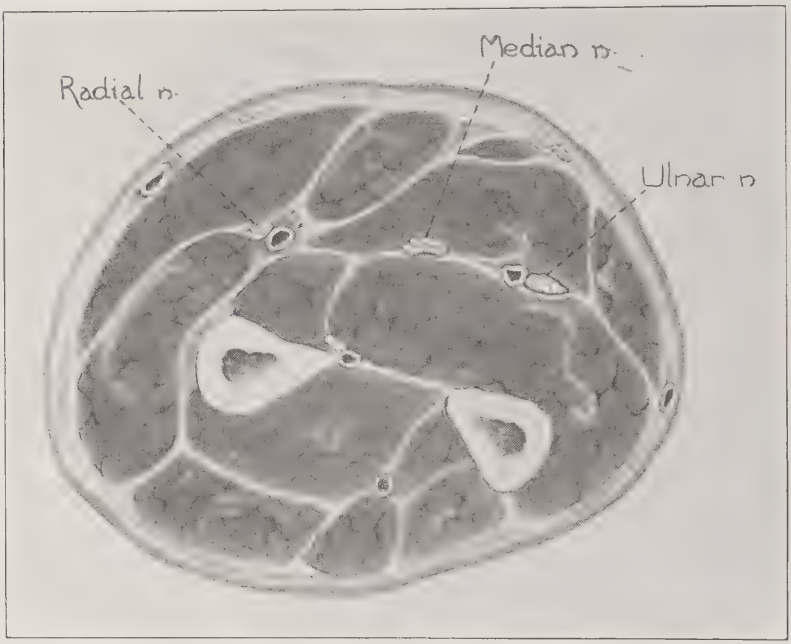


Fig. 24.—Cross section through the middle third of forearm showing locations of principle nerves.

in its socket to prevent a flattening of the shoulder which may be apparent through the clothing.

Anterior and posterior flaps of equal length are preferable in arm as in forearm amputations (Fig. 19). In wearing an artificial appliance the pressure is least upon the end and greatest upon the sides. Placing the scar on the end would then be the most desirable. The stump end should be absolutely smooth with freely moving skin and fascia over the bone ends. In amputation through the surgical

neck or disarticulation at the shoulder the skin and fascia flaps should be lateral and of approximately equal length placing the scar away from the point of the shoulder, where it would not be exposed to injury.

Technic of Arm Amputation.—As in the forearm, anterior and posterior skin-fascia flaps of equal length are used. Decide upon the point of section of bone and cut the muscles 4 cm. (1½ inches) longer. Treat the bone (Fig. 25), nerves (Fig. 26), and blood vessels as in the forearm. Group the muscles about the bone end with purse-string

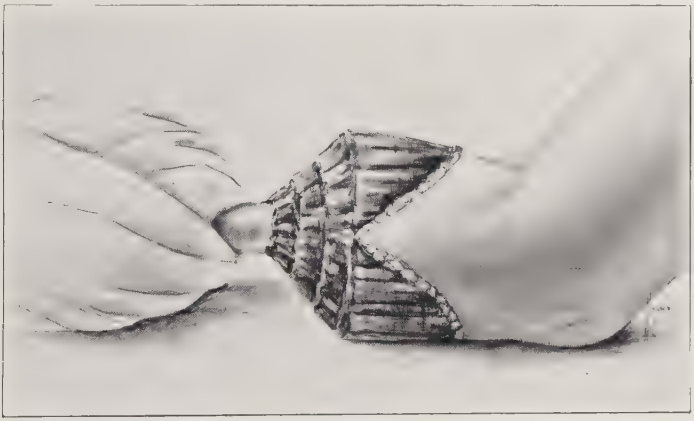


Fig. 25.—Cloth retractor for arm or thigh amputation.

sutures of chromic gut in a manner to prevent the bone from protruding and to give the muscles new insertions to bone and deep fascia. Mattress sutures may be used in addition to or instead of the purse-string suture. Carefully close the deep fascia over the muscles with interrupted chromic sutures. Close the skin with interrupted sutures of silk or silkworm-gut. Insert a rubber tube or other drainage down to the muscle from near each end of the incision. Apply a light snug dressing.

Technic of Amputation Below Humeral Head or Shoulder Disarticulation.—Medial and lateral skin-fascia flaps are made of nearly equal lengths (Fig. 27). These flaps ex-

tend downward to the insertion of the deltoid muscle. Divide carefully the muscles and other tissues down to the bone. A tourniquet is not necessary if all vessels are quickly clamped and ligated when cut. Divide the bone

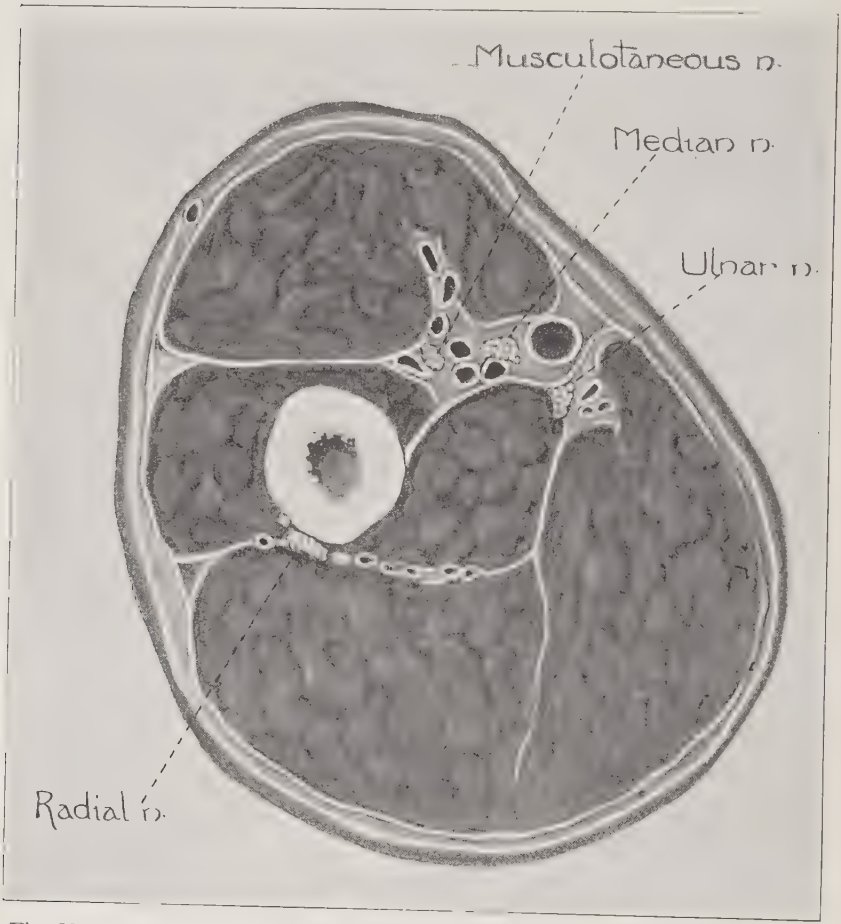


Fig. 26.—Cross section through the middle third of the arm showing locations of principle nerves.

near the head or disarticulate by cutting through the capsule. Shorten all nerves up to the axillary space and inject with 95 per cent alcohol. Preserve the circumflex so that innervation to the deltoid muscle may not be destroyed.

This nerve passes around the outer side of the surgical neck of the humerus and may be avoided by dissecting close to the bone. Close the muscles and fascias carefully so that all dead space possible may be obliterated. Insert a drain down to the joint. Suture the fascia and skin separately and apply a snug dressing.

Technic of Interscapulo-Thoracic Amputation.— (A) *Berger anterior method.* By this operation the arm, scapula and a part or all of the clavicle are removed. There is

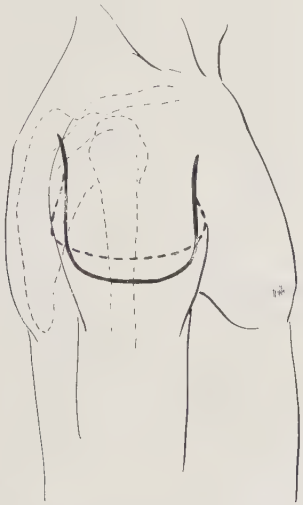


Fig. 27.—Lines of incision in disarticulation at the shoulder or amputation high through the surgical neck.

usually considerable bleeding and great care should be used in quickly clamping all vessels. Outline the incision as shown in Fig. 28. Remove the middle third or all of the clavicle as seems indicated. Before proceeding further, ligate and divide the subclavian vessels using care not to injure the lung or phrenic nerve. The skin flaps are next made, uncovering the scapula with its muscular attachments and exposing the pectoral muscles in front. The entire upper extremity with the attached clavicle and scapula is carefully cut away, clamping all bleeding vessels as

they are severed. The operation may cause considerable shock. Close the skin flaps and provide ample drainage. A snug dressing is essential to minimize oozing beneath the flaps.

(B) *Littlewood's*[1] *posterior method.* The technic of this operation is given in the author's own words. "The patient is placed on the sound side, close to the edge of the operating table. A cervicoscapular flap is made, commencing at the clavicle near the outer margin of the sternomastoid

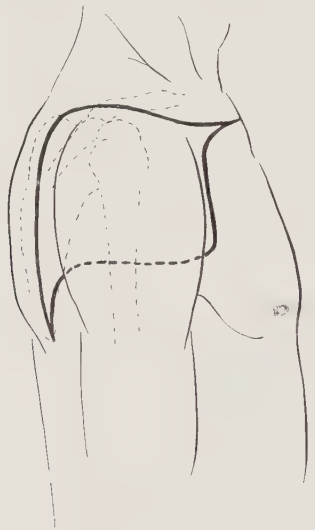


Fig. 28.—Lines of incision in interscapulo-thoracic amputation by the anterior method.

attachment, carried along the clavicle over the prominence of the shoulder along the axillary border of the scapula to a point below the angle and backwards to about two inches from the spine (Fig. 29). A flap of skin and subcutaneous tissue is rapidly turned back; this exposes the posterior surface of the scapula, with the muscles attaching it to the spine. The trapezius and latissimus dorsi are then divided, next the levator anguli scapulae, the rhomboids, and lastly

[1]Littlewood, H.: Brit. Med. Jour., 381, March 11, 1922.

the scapular attachment of the serratus magnus and the omohyoid muscles. Three or four vessels may require ligature, branches of the suprascapular and posterior scapular arteries. The soft tissues are now separated from the clavicle, close to the sternomastoid attachment, and the bone surrounded by a Gigli's saw and divided.

"The whole upper extremity now falls away from the trunk, held by the subclavian vessels and the cords of the brachial plexus, which are fully on the stretch, standing out and easily seen.

Fig. 29.—Skin incision used in interscapulo-thoracic amputation by the posterior method.

"The cords of the brachial plexus are now divided with a pair of scissors close to the spine; and injection of novocaine into the nerve can be given before division, as has been recommended to lessen the shock. Clips are applied to the subclavian artery which is divided between them; the vein is then seen and treated in the same way. The advantages of securing the artery first have been pointed out by so many operators, and in this operation it is the easiest plan. The vessels can now be ligatured or this can be done after the parts have been removed. The anterior or pectro-axillary flap is now cut and reflected as far forwards as necessary. The last stages in the operation consist in the

division of the pectoralis major and minor muscles. The position of the division depends on the extent of the muscles it may be thought necessary to remove.'' After removal of the lymphatic glands the skin flaps are sutured, drainage instituted and a firm dressing applied.

CHAPTER IV

AMPUTATIONS OF THE LOWER EXTREMITY

Foot and Ankle

General Remarks.—In amputations of the lower extremity the two chief factors to be considered are locomotion and weight-bearing. With this in mind no amputation should be done without full consideration of these two future functions of the extremity.

As a rule it is unwise to leave a single toe on a foot when the remainder are completely amputated. This applies to the great toe, as well as to the others. A single toe becomes painful and deformed and is not only useless but constitutes a disability greater than no toes (Fig. 30).

An amputation through the metatarsals will produce a good stump. The Lisfranc which is a tarsometatarsal disarticulation, will produce a useful stump, providing care is used to retain the function of the flexors and extensors of the foot, so that deformity will not result from contractures by loss of muscle balance. Any foot amputation proximal to the Lisfranc is of very doubtful value and should not be done as a definitive amputation. The Chopart, which is a mediotarsal disarticulation (Fig. 31), does not make a good stump because of the lack of muscle balance and consequent deformity due to contracture of the calf muscles tilting the scar downward so that it becomes weight-bearing surface (Fig. 8). The Pirogoff (Fig. 31) which is a bone plastic operation, designed to unite the posterior portion of the os calcis to the severed tibia and fibula just above the malleoli, is unsatisfactory because it is difficult to obtain good solid bony union in a good position and because of the extreme difficulty of fitting with an artificial foot. The stump is too long for a good ankle joint. Subastragaloid disarticulation

and other similar procedures have the same drawbacks as the Pirogoff. It is far better to jump from the Lisfranc to the Syme, leaving out the various operations in between as unsatisfactory from the standpoint of future function with artificial appliances.

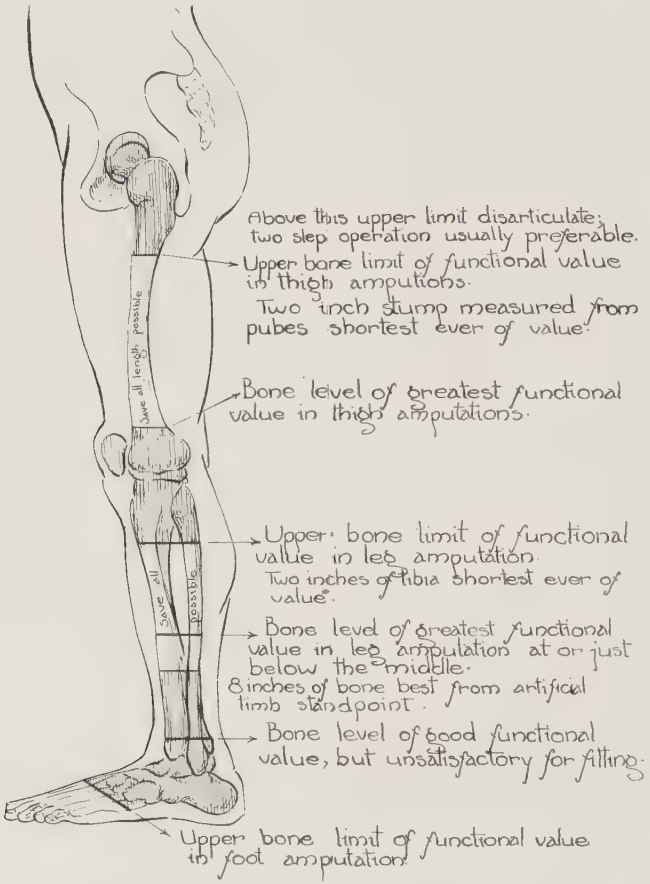

Above this upper limit disarticulate; two step operation usually preferable.
Upper bone limit of functional value in thigh amputions.
Two inch stump measured from pubes shortest ever of value.
Bone level of greatest functional value in thigh amputations.
Upper bone limit of functional value in leg amputation.
Two inches of tibia shortest ever of value.
Bone level of greatest functional value in leg amputation at or just below the middle.
8 inches of bone best from artificial limb standpoint.
Bone level of good functional value, but unsatisfactory for fitting.
Upper bone limit of functional value in foot amputation.
Save all length possible
Save all possible

Fig. 30.—Locations of choice for amputations in the lower extremity. (Military Surgeon.)

The Syme, which is an amputation just above the malleoli, makes a good end-bearing stump (Figs. 32 and 33), and is of sufficient length to enable a patient to go about his room without a crutch or artificial limb. The drawback to the

Syme is the difficulty encountered in fitting without producing a wide unsightly ankle. The advantages of a good Syme are, as a rule, sufficient to offset the poor cosmetic results.

Technic of Toe Amputations.—Long plantar flaps are used in all cases when of sufficient length to make a closure

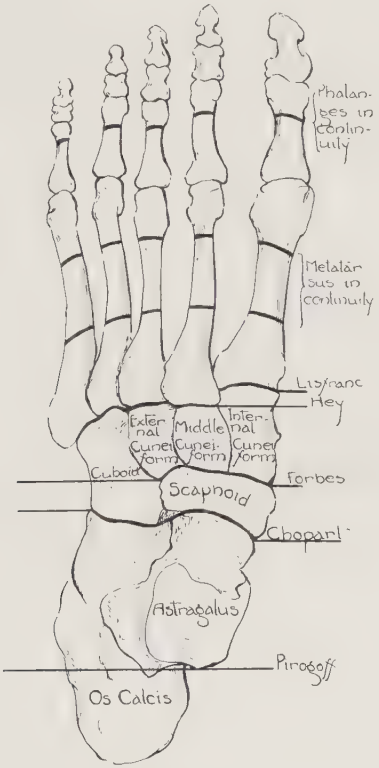


Fig. 31.—Skeletal lines of incision in several of the well-known foot amputations.

without tension. Because of the shape of the toes, it is sometimes difficult to outline the flaps so that they fit accurately. With care much irregularity in the suture line is avoided and rapid healing promoted with resultant smooth scar. Care is exercised in cutting the bone so that it may not be splintered, which can ordinarily be done with sharp

bone cutting forceps. Other tissues are of little importance if a good pad of skin and subcutaneous fat forms the end of the stump. Drainage is not usually required unless infection exists.

Technic of Metatarsal Amputation.—A long plantar and a short dorsal flap is made (Fig. 34). Everything is severed

Fig. 32.—A good stump following a Syme amputation.

Fig. 33.—Amputation at the ankle without removal of the malleoli necessitating reamputation.

down to the bones which are cut across with a saw. The periosteum is carefully removed from the bone ends for a distance of two millimeters (¼ inches). Tendons and muscles are sutured together or to the bone ends to promote smooth healing and prevent retraction. The plantar pad of fat and fascia is sufficient to insure a firm stump. As elsewhere, the flap is carefully shaped and smoothly sutured. It is advisable to place one small drain of rubber tubing or rubber tissue beneath the flap for thirty-six to

Fig. 34.—Lines of incision in metatarsal or Lisfranc amputations.

forty-eight hours to drain off blood and serum. A firm dressing is applied which should be changed in twenty-four or forty-eight hours.

Technic of the Lisfranc Amputation.—The technic for this amputation is much the same as that of the metatarsal (Fig. 34). The joints between the tarsals and metatarsals are disarticulated (Fig. 31). It is quite important to suture the chief tendons to the periosteum to strengthen the insertions of some and to give others new insertions. This is especially true of the tibialis anticus, tibialis posticus and the peronei muscles. Without such attachments there may

result a muscle imbalance due to contracture of the posterior muscles which will impair the function of the stump. The plantar flap should be of sufficient length to cover well the end of the stump so that the pressure of an artificial form to fill out the shoe will not cause irritation. Careful closure of the skin is made to make a smooth scar. Use drainage and firm dressings.

Fig. 35.—(A) Line of incision for Syme amputation. (B) Method of disarticulation at the ankle.

Technic of Syme Amputation.—(Figs. 35, 36, and 37.) Skin incisions are made down to the bone. The most careful portion of the operation then follows. The heel flap is cautiously cut away from the calcaneum close to the bone without injuring the arteries on each side as they pass below the malleoli. The large and well-defined posterior tibial passes on the medial and the terminal branches of the peroneal extend downward on the lateral side of the fibula.

Preservation of these vessels often means the success of the operation and their destruction may result in sloughing of the flap and failure. When the flap is entirely freed it is

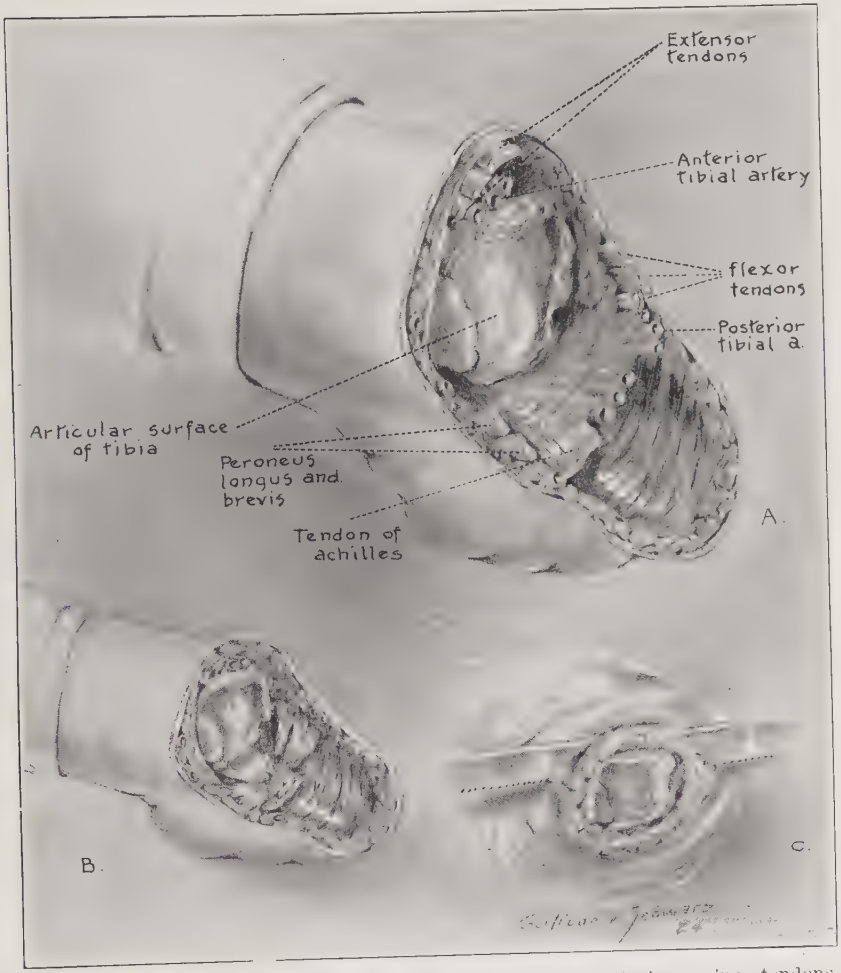


Fig. 36.—(A) Foot has been removed showing the arteries, veins, tendons and articular surface of the tibia. (B) Posterior tendons are sutured to the tendo-achilles. (C) Removing the articular surfaces of the tibia and fibula.

retracted and the malleoli sawed through just above the articular surface. The periosteum is then removed from the end of the bones for about one-half centimeter (¼ inch).

The posterior tendons are sutured to the tendo achillis and the anterior tendons are attached to the periosteum or to the heel flap, which is swung forward and sutured as smoothly as possible. There will invariably be some puckering which can be shaped to some extent after the suturing has begun. It may be wise to later do a slight plastic operation if too much puckering occurs. Care is necessary not to interfere with the blood supply at this point when attempting to shape the flaps. Drainage is desirable. A snug

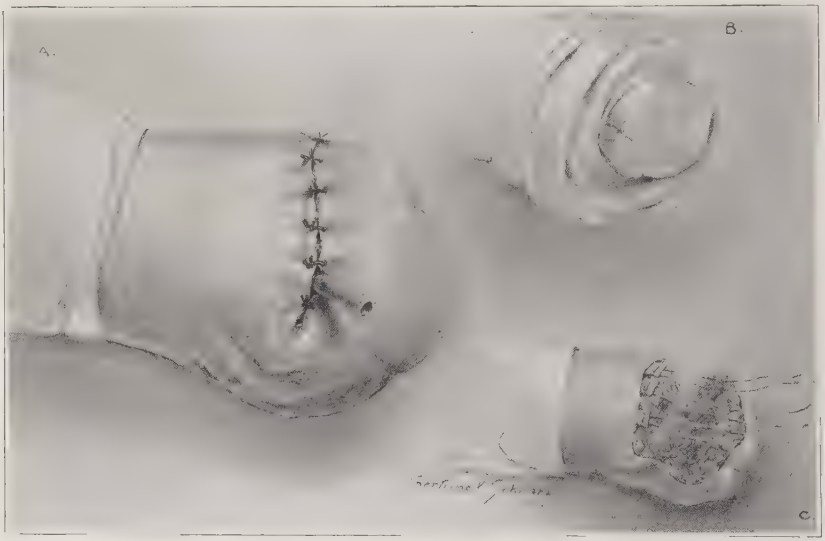


Fig. 37.—(A) Completed operation with rubber tube drain placed beneath the heel flap. (B) Shows removal of periosteum above cut end of bone. (C) The extensor tendons are sutured to the heel flap.

dressing is applied to prevent the accumulation of blood and serum beneath the heel flap. This is important because there is a tendency to formation of space in this location.

Leg

General Remarks.—Above the location of the Syme, the best stump is made by amputating through the middle third of the leg (Fig. 30), preferably seven or eight inches below the knee. Amputation through the lower third is unsatis-

factory because most of such stumps become atrophic, tender and cyanotic. A leg stump shorter than three inches cannot be satisfactorily fitted and in such a case an amputation just above the knee will give greater function. The old term "site of election" should be abandoned. It means an amputation about four inches below the knee, so that a kneeling stump may be used without the end of the stump

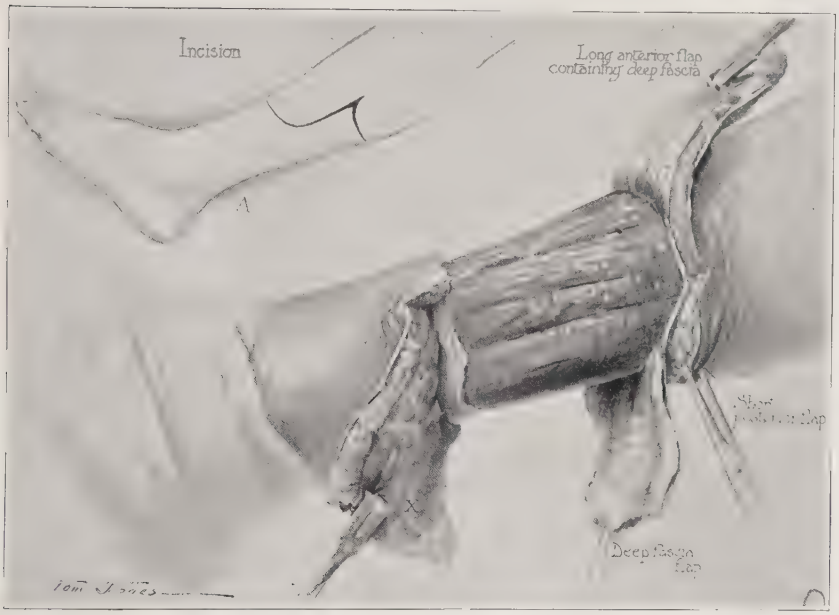


Fig. 38.—Shows incision, skin and fascia flaps.

projecting too far posteriorly for convenient use of a peg leg.

Technic of Leg Amputation.—(Figs. 38, 39, 40, 41, 42, and 43.) It is usually advisable to use a tourniquet which may be placed to advantage just above the knee. The deep fascia is included with the anterior flap. The short posterior flap is not dissected from the fascia. The skin and subcutaneous tissues are cut from the deep fascia downward, and a fascial flap freed which is somewhat longer than the diameter of the stump. These flaps are

separated from the muscle to the point of section of the bone or a little higher. The leg is then circled with the knife, cutting all tissue to the bone about 4 to 5 centimeters

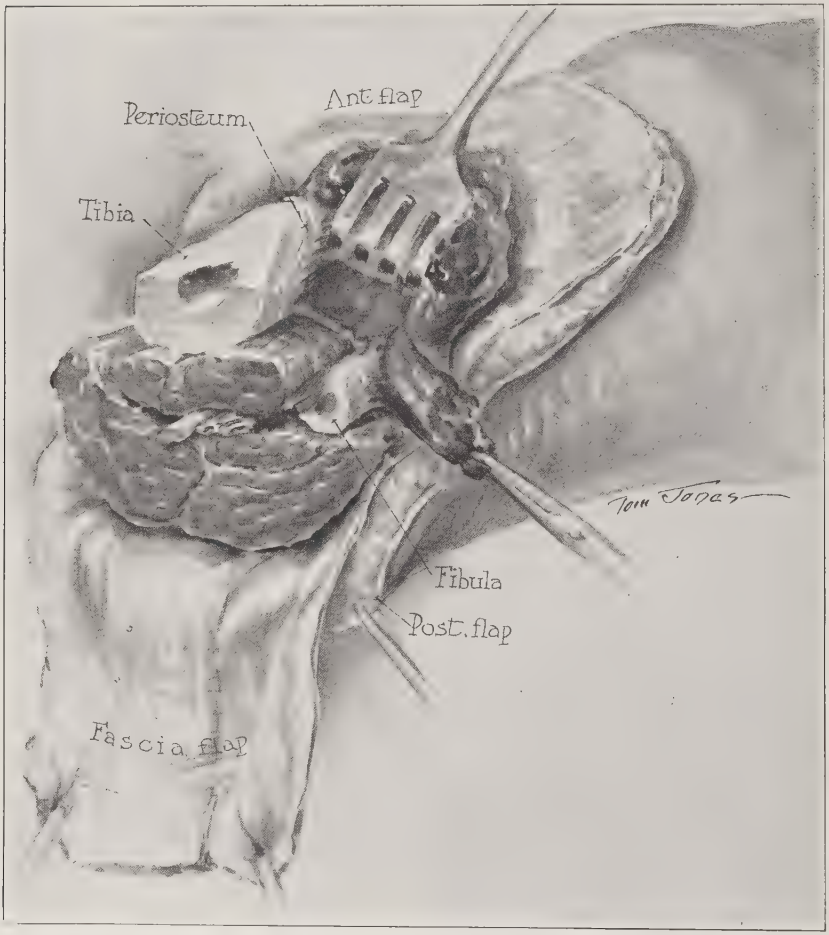


Fig. 39.—Method of treating the bones and muscle. The fibula is cut shorter and the muscle slightly longer than the tibia.

(1½ to 2 inches) distal to the point of bone section. All tissues are separated from the bone to a height sufficient to cut the bone across with a saw (Fig. 44). The bones are freed from periosteum at the site of section and sawed

across, making the fibula 1 to 2 centimeters (½ to ¾ inch) shorter than the tibia. If the fibula is left as long as the tibia it is apt to be prominent and movable and will very likely become tender, producing a stump difficult to fit comfortably. It may be wise, in very short leg stumps, to remove the fibula entirely to give better tibial weight-bearing surface. The aperiosteal method is used here as in all

Fig. 40.—Injecting a nerve with absolute alcohol after the method of Lewis and Huber.

amputations. The periosteum is carefully removed with knife and curette for at least one-half centimeter (¼ inch from the cut end of the bone. The tibial crest is removed with the saw for a distance of about 2 to 3 centimeters (1 inch) to avoid its protrusion beneath the skin. The bone edges are made smooth with either rongeur or coarse file. The nerves are isolated (Fig. 45), drawn downward out of

the tissues as far as possible, injected with 95 per cent alcohol, and divided just distal to the injection. All bleeding points are carefully ligated with catgut. The muscles are then grouped about the bone end by surrounding them with a purse-string suture of chromic catgut. If the bulk of the muscle be too great, a wedge-shaped section may be re-

Fig. 41.—This shows the muscle grouped about the bones and held together by a heavy purse-string suture.

moved at the sides to avoid a bulbous stump. Additional mattress sutures may be added if necessary to properly group the muscles. The fascia of the posterior flap is then sutured over the end of the stump and to the muscle, carefully covering all muscle. The proper grouping of the muscles about the bones and careful covering with fascia affords an opportunity for a new and firm insertion for the cut ends of the muscles. Over this the anterior skin-fascia

flap is turned and the fascia sutured to the first fascial layer. The skin is closed with interrupted silk or silkworm-gut with a small rubber tube for drainage near each end of the wound. The drains are never placed in the angle of the wound, but between stitches. By this means smoother healing results. The cut edge of the anterior flap is always

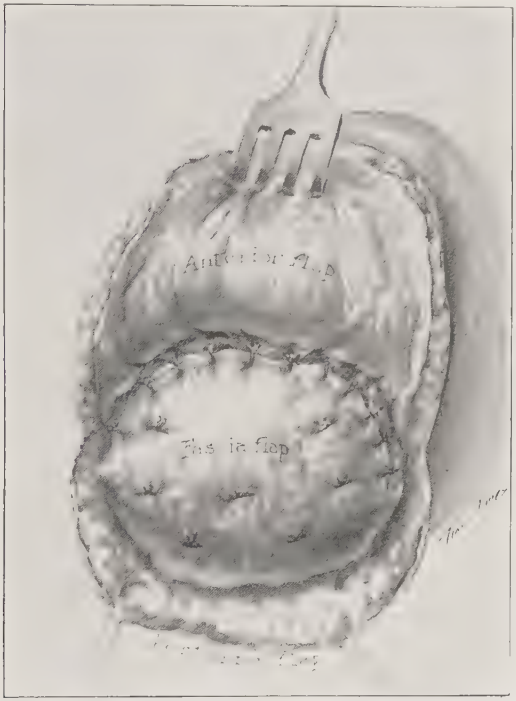


Fig. 42.—Posterior fascial flap sutured over the end of the bone and muscle group. The sutures through this flap reach into the cut end of the muscles to fix them firmly to the flap and to obliterate dead space.

longer than the posterior which should be taken into consideration when closing the wound. By placing the sutures at a slightly greater distance apart on the anterior than on the posterior flap, it will be possible to avoid puckering at one end of the wound. A firm dressing is applied which is usually removed in twenty-four hours to relieve pain produced by swelling.

Fig. 43.—The finished stump with drain in the posteriorly placed incision.

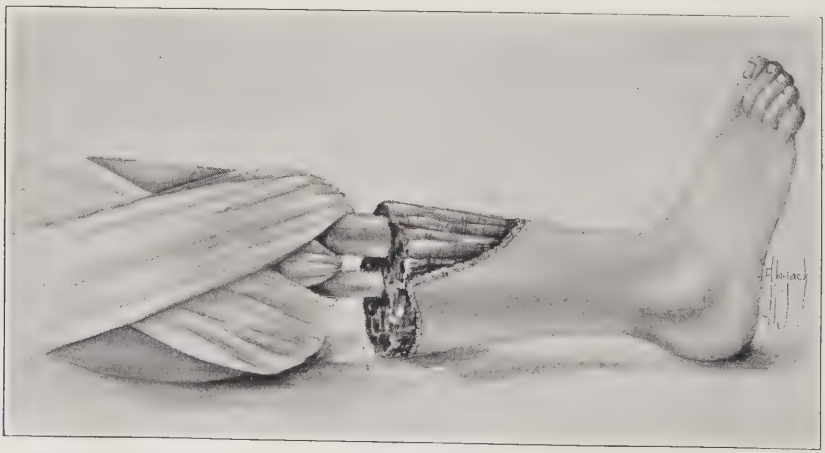


Fig. 44.—A three tailed cloth retractor which may be used in leg and forearm amputations.

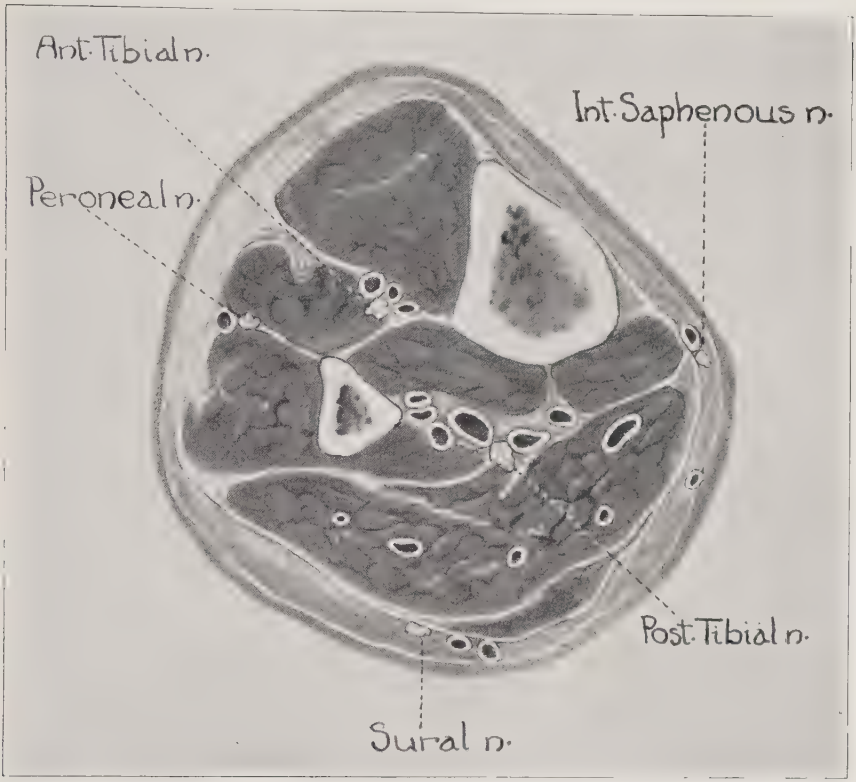


Fig. 45.—Cross section of the leg in the middle third showing the principal nerves.

Thigh

General Remarks.—A thigh stump should be made as long as possible, but amputation should not be made through the knee joint because of the resulting bulbous stump which is difficult to fit and when fitted presents an unsightly appearance. Knee-joint disarticulation has no advantage over the Gritti-Stokes or supracondylar amputation (Fig. 30).

The Gritti-Stokes, which is an osteoplastic amputation at the knee, when properly done, is useful and makes a good end-bearing stump (Fig. 46). It requires considerable care in operating and after-treatment to obtain the best results.

Fig. 46.—Training the Gritti-Stokes stump to become end bearing.

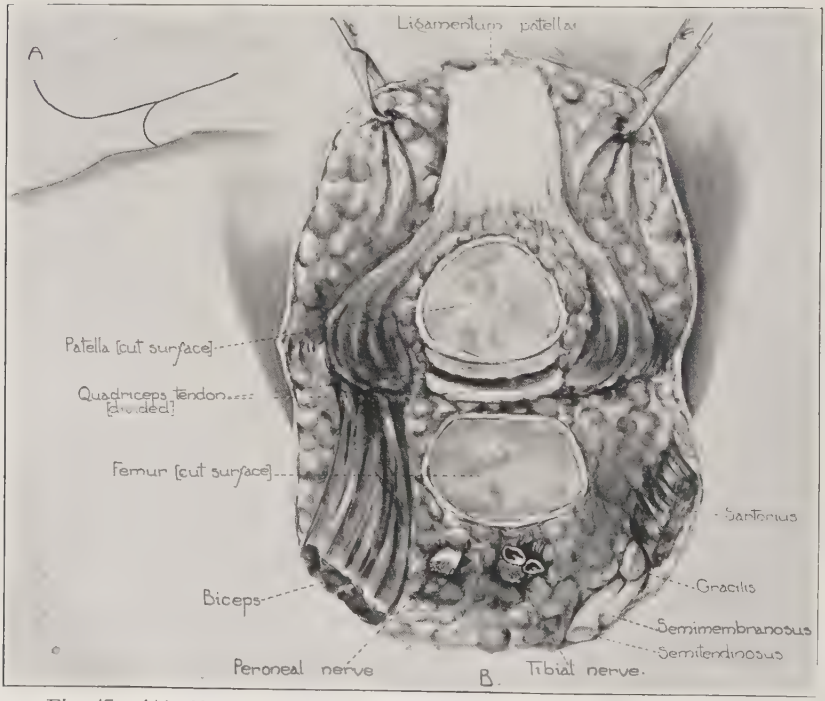


Fig. 47.—(A) Skin incision for Gritti-Stokes amputation. (B) This shows anterior flap including the patella and patellar tendon. The quadriceps extensor tendon has been cut across. The articular surface, including about one-half of the patella, has been removed by the saw. The femur has been divided above the condyles.

A thigh stump shorter than two inches measured from the perineum, has no more value from the standpoint of fitting than a hip-joint disarticulation. It can be fitted, as can the latter, with a special type of limb having a firm

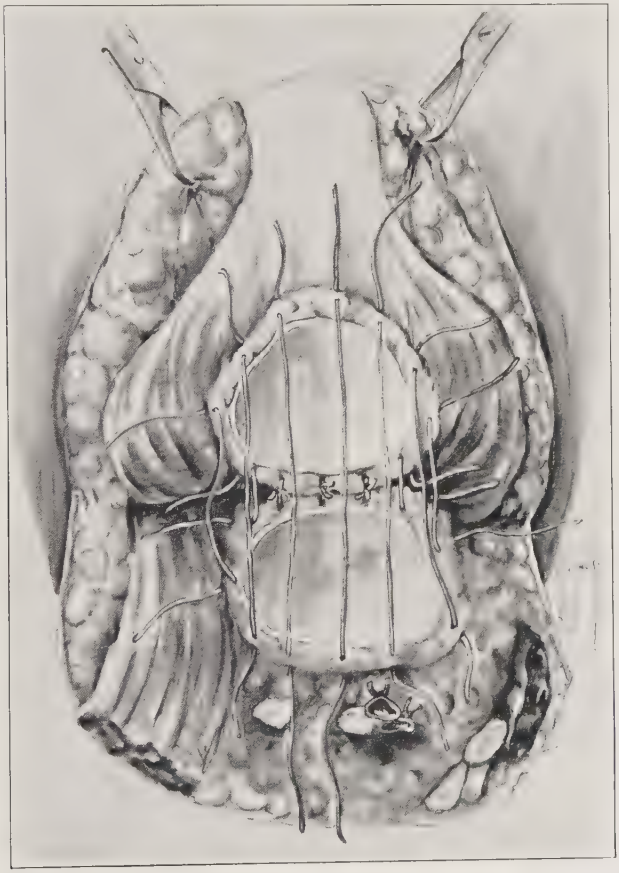


Fig. 48.—Same as Fig. 47 with sutures placed to suture patella firmly to cut end of femur.

pelvic girdle. These amputations are always undesirable and should be avoided whenever possible.

Technic of the Gritti-Stokes Amputation.—(Figs. 47, 48, 49 and 50.) A long anterior and a short posterior flap is made. The incision for the anterior flap is made across the

tubercle of the tibia. The patellar tendon is severed near its insertion and a portion of the tendon preserved for future use. The anterior flap includes the patella and all

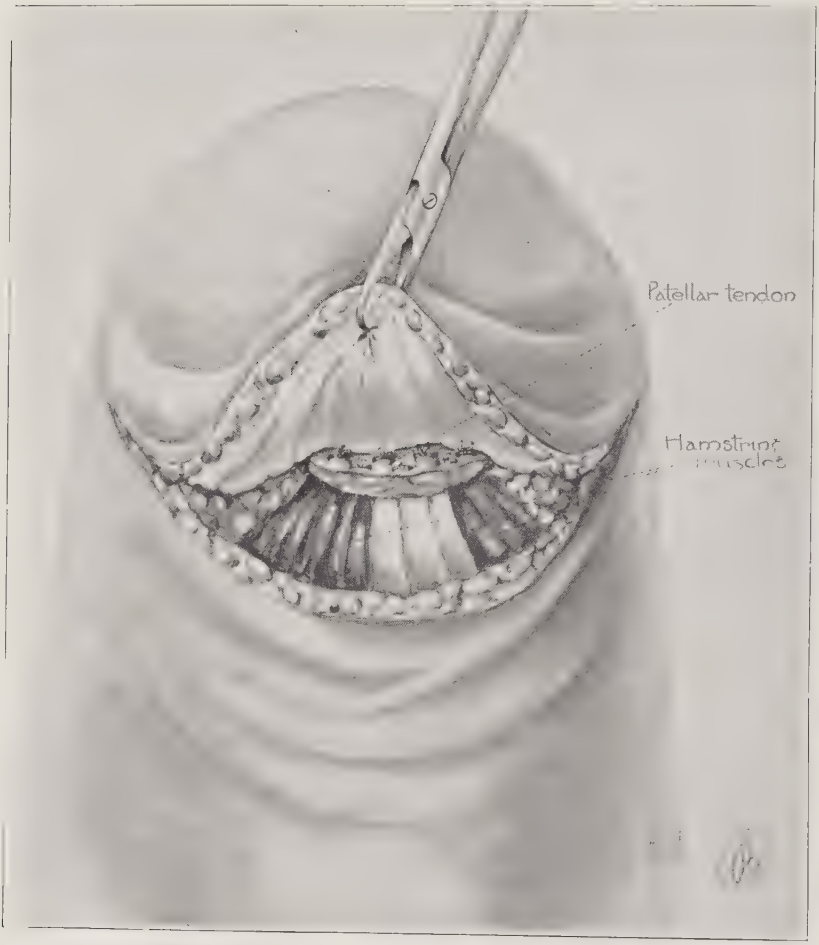


Fig. 49.—The Gritti-Stokes amputation. Shows method of suturing muscles and tendons to patellar ligament to give them a new insertion and to counterbalance the opposing muscle pull.

other tissues down to the joint. The posterior flap is short and is not dissected up more than two or three centimeters (½ to 1 inch). The hamstring muscles are cut at their insertions and preserved. The patella is turned back and its

articular surface sawed off. The femur is divided just above the condyles at a point where the cut end of the bone will be approximately the same size as the cut surface of the patella. All synovial membrane is removed. Just above the patella, the tendon of the quadriceps extensor is divided to prevent the strong pull of that muscle tilting the bone during healing (Fig. 51). By the time the patella

Fig. 50.—Finished Gritti-Stokes amputation. Rubber tube drain is placed deep in the wound from each side.

is united to the femur, the severed tendon will have healed. The nerves are injected with 95 per cent alcohol and shortened. Hemostasis receives careful attention. Excess fat and muscle tissue is removed. The patella is sutured snugly down on the cut end of the femur by interrupted chromic gut sutures through the fascia surrounding each bone (Fig. 52). The gracilis, sartorius, semitendinosus and semimembranosus, with the biceps on the opposite side are made the

Fig. 51.—Gritti-Stokes amputation. The patella has been tilted by the pull of the quadriceps extensor before it could unite to the femoral shaft. FX.

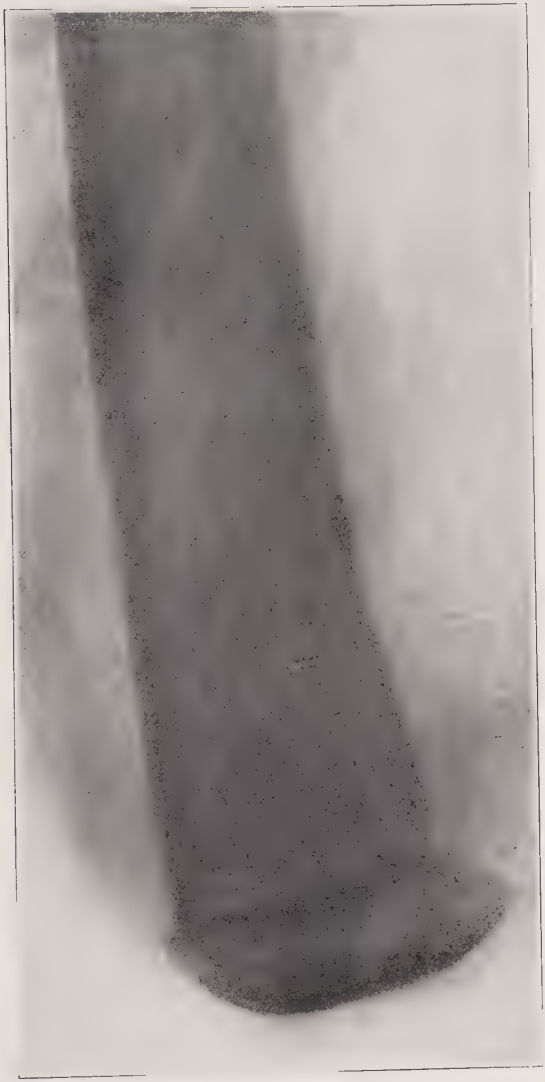


Fig. 52.—Gritti-Stokes amputation. Patella has been properly placed.

proper length to suture snugly to the patellar tendon. The suture of these muscles and tendons gives them a new insertion and balances the pull of the quadriceps extensor. Over this the deep fascia and skin are closed in separate layers. Interrupted sutures of silkworm-gut or other nonabsorbable material is used in the skin. A small drainage tube is inserted between stitches near the angle of the wound on each side. It is dressed at first as any other stump. As soon as the wound is healed and the stitches removed, it is wise to

Fig. 53.—Plaster cap that may be used during bone healing following a Gritti-Stokes amputation.

run a wide strip of adhesive across the end in two directions to make firm pressure over the patella. In addition to this a plaster of Paris cap (Fig. 53) may be applied to protect the stump end until the patella has united. After six or eight weeks a temporary limb is fitted and light end-bearing begun.

Technic of Amputation Through the Thigh.—The site of the bone section is chosen. Here, as in the leg, the long anterior and short posterior flaps are made (Figs. 54 and 55). The deep fascia is included with the skin flaps. About

8 centimeters (3 inches) below where the bone is to be cut, the muscles are divided around the thigh. The periosteum is then cut through about the bone in a circular fashion and with a curette removed downward for a centimeter. The

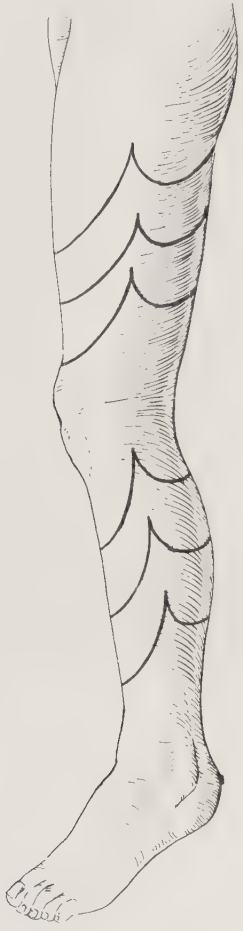


Fig. 54.—Lines of skin incisions for leg and thigh amputations.

bone is sawed across leaving about one-half centimeter (¼ inch) of the bone end free of periosteum. The important nerves are then drawn down (Fig. 56), injected with alcohol and divided distal to the injection. All bleeding ves-

sels are ligated. The muscles are grouped about the bone end and to each other with a purse-string suture of chromic gut or with multiple mattress sutures of the same material. The deep fascia is carefully sutured over the grouped muscles. This fascia is the normal envelope of the muscle and should be used to cover the stump end when possible. The same technic as used in the leg may be used here making a double layer of deep fascia over the end of the stump. Closure of the skin is best made with interrupted sutures

Fig. 55.—Faulty shaped flaps of thigh amputation. Note the redundant puckered tissue at the end of the scar.

of silk or silkworm-gut. A rubber tube drain is inserted between sutures down to the muscle near each end of the incision.

Technic of Disarticulation at the Hip or Amputation Through the Femoral Neck.—The method of Huggins[1] is suitable for this operation. He emphasizes the importance of not leaving any redundant muscle or skin in hip-joint amputation. After healing, the stump must be smooth. Loose flabby skin or excess muscle interferes much with fitting of an artificial limb. The incision is made as shown

[1]Huggins, G. M.; Amputation Stumps, Their Care and Treatment, Oxford War Primers.

in the accompanying illustration (Fig. 57). That portion over the femoral vessels is made first and the vessels divided between strong ligatures. It is then extended inward for a short distance along Poupart's ligament, then downward and backward three and one-half inches below the perineum, continuing around the thigh to the lower end of

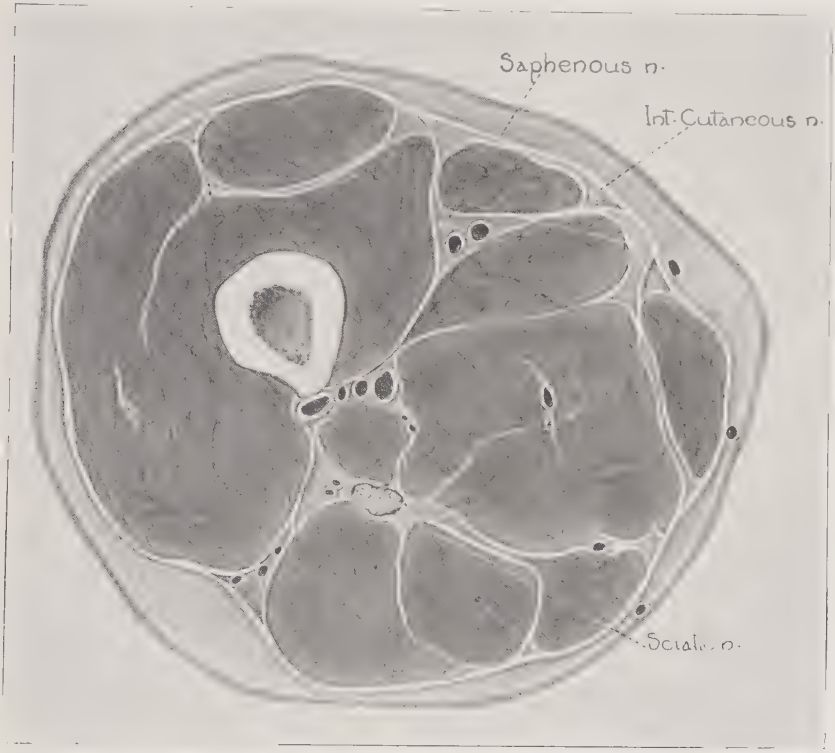


Fig. 56.—Cross section of thigh through the middle third showing the principle nerves.

the vertical incision. This flap with the deep fascia is dissected up to a level with the hip-joint. The muscles are divided close to the bone beginning with the adductors. Bleeding vessels are clamped as they are divided. Amputation may be done through the neck with a Gigli saw, or the head disarticulated. This is usually done before the

hamstrings and gluteus maximus are cut. The sciatic nerve is severed high to prevent a tender neuroma near the ischium which is the weight-bearing point. All other nerves are treated as in other amputations. A portion of muscle is sutured over the acetabulum to prevent the skin at this point forming a sulcus after healing. The skin flaps as made will not fit and must be shaped as the closure is made. Suturing is begun with the vertical incision. The postero-

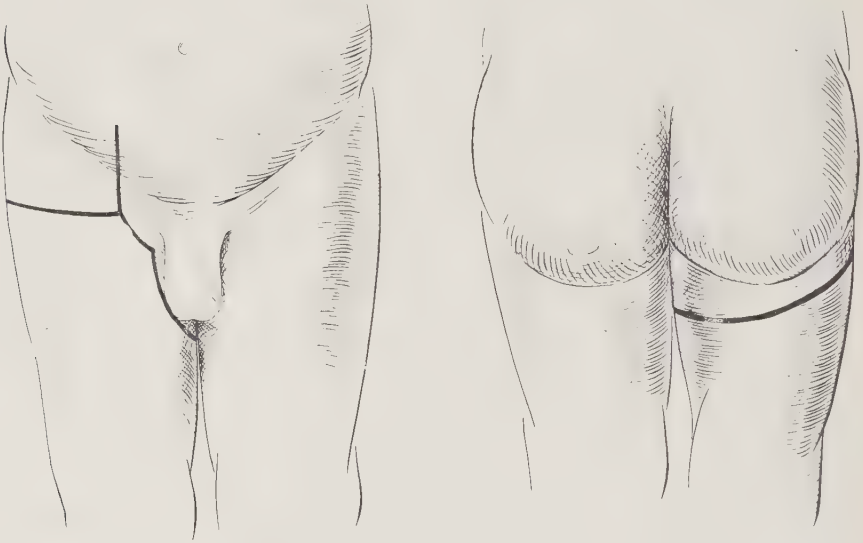


Fig. 57.—Incisions for disarticulation at the hip. For an accurate closure of the skin some trimming of the flaps is necessary. (Redrawn from Huggins.)

internal flap is then sutured to the anteroexternal flap beginning at the inner side of the thigh. Excess skin and fascia must be removed. When the outer portion of the suture line is reached, a V-shaped section must be cut from the lower flap to effect a fit. Liberal drainage is instituted. A snug dressing is applied to prevent collection of blood and serum beneath the flap.

CHAPTER V

CINEMATIPLASTIC AMPUTATIONS

In the year 1896, Dr. Guilian Vanghetti introduced the method of cinematization of amputation stumps. While his early work was entirely experimental, it has been the stimulus for practical application of the method and to him should be given the credit of its development. Ceci of Pisa was the first surgeon to use Vanghetti's method on the human. Since then, the work has reached its greatest stage of development in Germany, under the leadership of Sauerbruch, in South America by G. Bosch Arana, and in Italy by Putti, Pellegrini and others. Very little of such surgery has been done in America or England.

Putti[1] defines cinematization of a stump as "any kind of surgical proceeding, be it bloodless or operative, which helps to make possible the direct transmission of voluntary movement from the stump to the artificial limb." Artificial points of attachment are made on the stump which are called plastic motors, to which are fixed cords that transmit movement to the artificial appliance.

It is somewhat difficult to accurately estimate the practical value of cinematiplastic amputations. Certainly good and worth while results have been obtained by some, and the procedure is worthy of every scientific consideration. Putti[1] writes the following: "The practical results that have been obtained through cinematization have convinced me that the hopes aroused by the principles and methods of the modern surgery of plastic motors are thoroughly well grounded. Cinematic plastics are entitled to be placed among the most brilliant of the discoveries of orthopedic surgery, deserve to be accepted with perfect confidence, and

[1]Putti, Vittorio: Medical Record, 95, 1004, June 14, 1919.

to be tested on a large scale by all those whose aim it is to restore to the disabled man his functional activity." Arana[2] states that "cinematiplastic amputation has won an

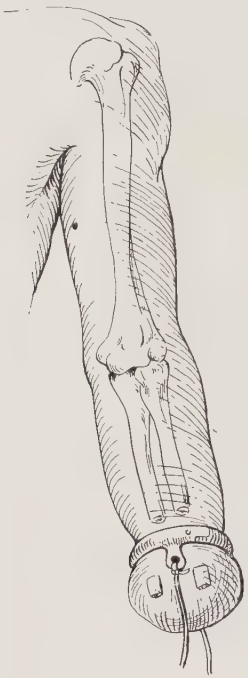


Fig. 58.—Club (clava) motor of forearm. (De Francesco.)

Fig. 59.—Loop (ansa) motor of forearm. (Warbasse.)

indisputable place in the domain of surgery. Today no one can question its well earned and tangible results."

[2]Arana, G. B.; Surg., Gyn. and Obst., 35, 347, September, 1922.

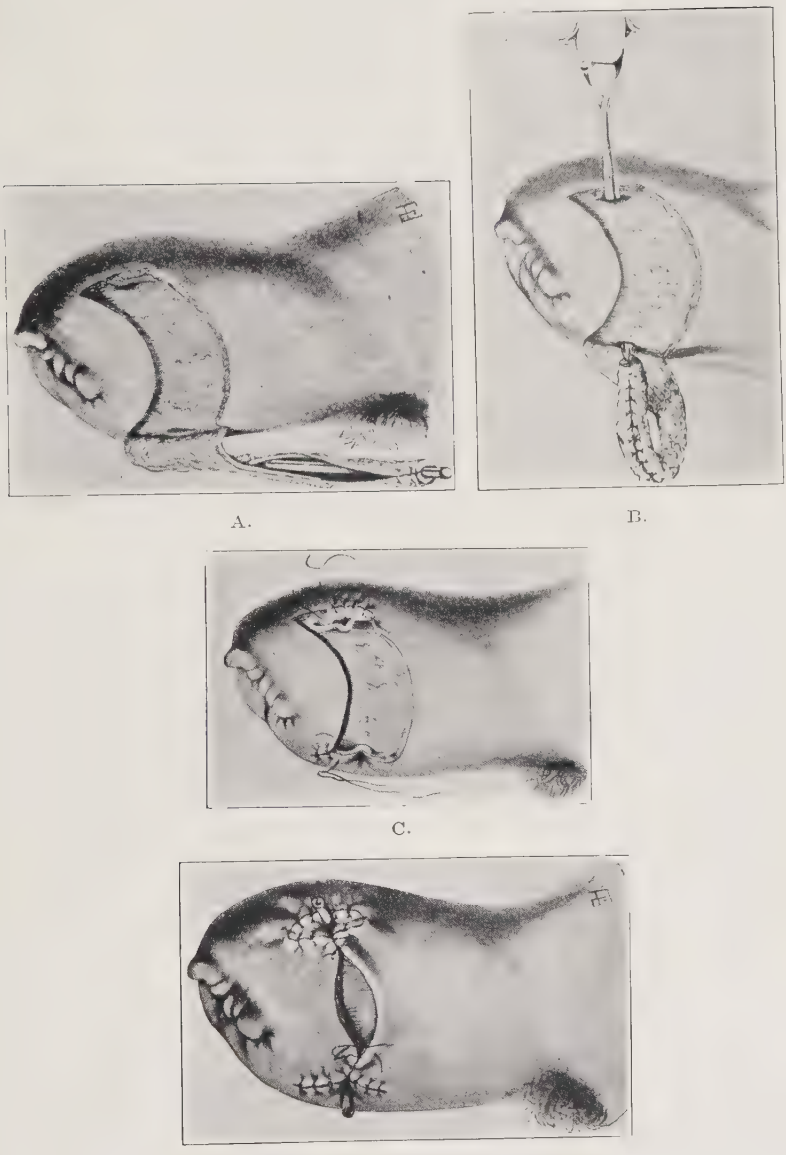


Fig. 60.—The Sauerbruch method of producing a cinematiplastic arm stump. (A) A skin flap is freed and a tunnel bored through the biceps muscle. The skin flap is sewed around a piece of rubber tubing with the epithelial surface turned inward. (B) The epithelial-lined tube is drawn through the tunnel in the muscle. (C) The end of the tube is sutured to the surrounding skin. (D) The skin wound is united with sutures. The now epithelial-lined tunnel is kept patent with a piece of rubber tubing.

Fig. 61.—Cinematiplastic amputation of forearm with prosthesis holding drinking glass. Button and cords attach motor to hand. (Vanghetti.)

Fig. 62.—Unimotor of forearm. (Warbasse.)

To actually put muscle and tendon to work much in the same manner as that designed by nature is little short of ideal. The future will sift out the worthless procedures

Fig. 63.—Bimotor of leg which will flex and extend foot. (Warbasse.)

Fig. 64.—Bimotor of forearm. (Vanghetti.)

and give us the practical workable cinematized amputation stumps which will become standard surgery for us all. To accomplish this end closest cooperation must exist between the surgeon and expert artificial limb workers.

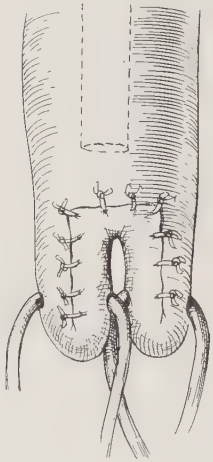


Fig. 65.—Bimotor of arm with rubber tubing through tunnels. (Vanghetti.)

Fig. 66.—Double motor (bimotor) of leg. (Drawn from photograph by Arana.)

Cinematiplastics find their greatest field of usefulness in the arm and forearm. Good results have been obtained in the lower extremity but the double function of weight-bearing and locomotion do not require the finer movements to perform these functions as do the arm and forearm with their numberless uses. Power of muscular extension at the

Fig. 67.—Double cinematiplastic amputation fitted with prostheses from Rizzoli Institute, Bologna. (Arana, Del Valle & Wildemuth.)

knee is very desirable and it is at this location that a plastic motor may be very serviceable.

. Plastic motors may be divided into club (clava) (Fig. 58), loop (ansa) (Fig. 59) and those constructed by tunneling the muscle masses (Fig. 60). The club or clava motor is created by making a knob-like ending of the tendons or muscle covered by normal skin. In this ending may be included some bone which has been severed from the bone

shaft and enclosed within the club to give it size and shape. Above the end or about the neck of the club may be attached a belt or ring through which its power is transmitted. The loop or ansa motor is constructed so that the muscles or tendons form a loop for the attachment of rods or cords extending to the artificial limb (Fig. 61). The tunnel motor is made by making a channel through the muscle which is lined with sound skin and through which a rod or rubber tubing may be worn to transmit its power

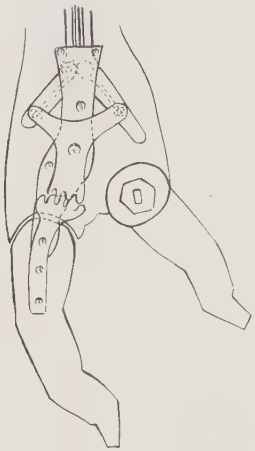


Fig. 68.—Cineplastic hand for a bimotor of forearm constructed by Fusaroli, Rizzoli Institute, Bologna. (Arana.)

(Fig. 60). Of the three, the club motor is the simplest and easiest of construction.

A plastic motor to be efficient must have sufficient muscular power, healthy skin covering, range of motion sufficient to move the prosthesis, sufficient length and strength and a good solid surface for counter pressure. The range of motion of the motor should be at least one inch, or better, one and one-half to two inches. Usually two motors are all that are advisable, because of difficulties in fittting them to the prosthesis. It is to be remembered, however, that unimotors, bimotors or plurimotors may be used in locations

and under conditions suitable for their construction and adaptation (Figs. 62, 63, 64, 65, and 66). These motors may be either terminal or lateral. Those placed on the end of the stump are simplest of construction, and usually have greatest range of motion, but often do not lend themselves

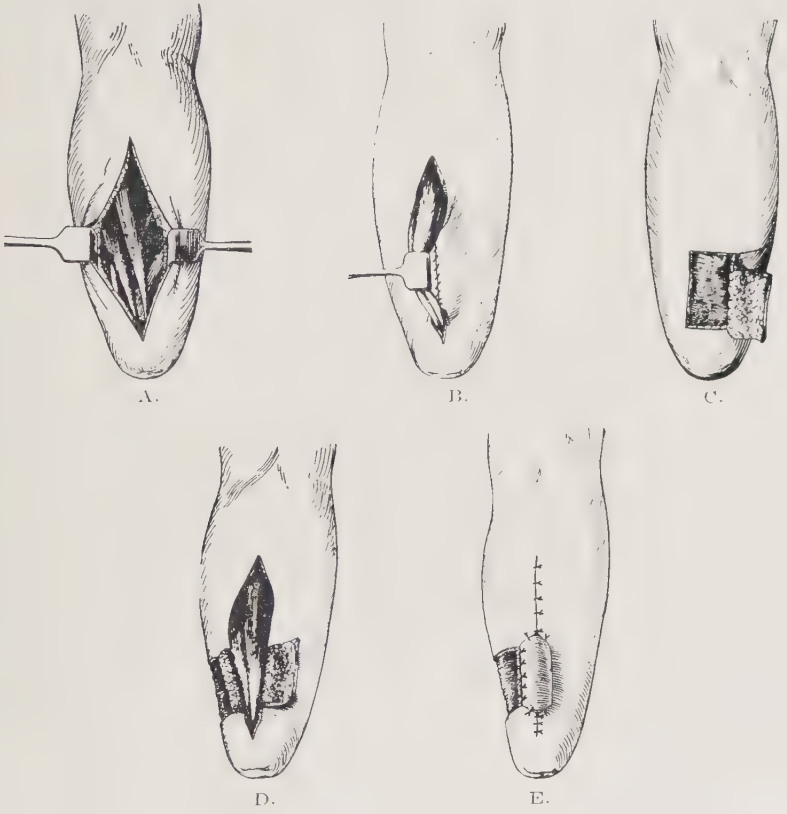
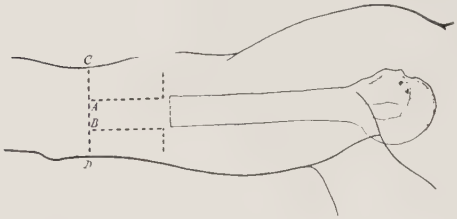


Fig. 69.—Method of constructing lateral motor of forearm. (A) Anterior forearm tendons exposed. (B) Skin sutured under tendons. (C) Flap raised from dorsum of forearm. (D) Skin flap placed beneath muscle and tendon. (E) Skin flap sewed around muscle and tendon. (Warbasse.)

to the complicated motion required in the artificial hand (Figs. 67 and 68).

It may not be possible in a great many instances to do a primary cineplastic operation, but stumps can be prepared at first operation for future cinematization. This entails



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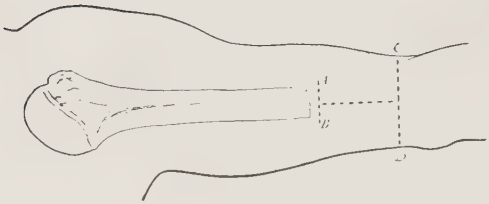

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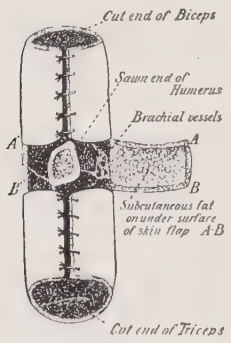

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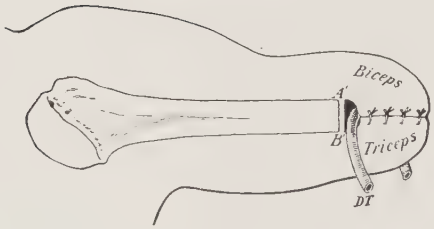


D.

Fig. 70.—Technic of cinematiplastic amputation of arm used by Dr. A. P. C. Ashhurst. (A) Inner surface of arm; the flap, AB, is to be used to cover the end of the bone; circular amputation at CD. (B) Outer surface of arm; the flap, AB, is sutured to the line A'B'. (C) Diagrammatic view of the end of the stump. The flap, AB, is sutured to A'B', and the skin overlying the muscular flaps is sutured around them as a cylinder. (D) The biceps has been sutured to the triceps, and a rubber tube is passed through the loop before dressing the stump.

the conservation of all tissue possible at the primary operation. The final operation must be a careful painstaking plastic procedure (Figs. 69 and 70) with the thought in mind that the motor must be constructed to withstand a firm, resisting and painless grip, and possess a high traction force. After a motor is healed, early motion and exercise is advisable to develop and strengthen the muscle and avoid permanent changes by contractures and scarring that would limit its usefulness.

CHAPTER VI

ARTIFICIAL LIMBS AND ARTIFICIAL LIMB FITTING

General Remarks.—In discussing artificial limb fitting, E. Muirhead Little[1] remarks that "In order to produce good results the surgeon and the limb maker must have some knowledge of each other's limitations." This statement is fully appreciated by all surgeons interested in amputations. A patient with an amputation which is to be fitted, should receive the same watchful care by the surgeon that is given to the patient requiring a brace or other artificial prosthesis.

The fitting of limbs in the upper and lower extremities presents very great differences. Generally speaking, fitting limbs is more important and less difficult in the lower extremity. The many and intricate functions of the upper extremity as compared to the simple functions of weight-bearing and locomotion of the lower extremity present obvious problems that are difficult of solution. In most cases, an amputé with the loss of the lower extremity is more disabled than one with an amputation of the upper extremity. The problem of limb making is greater in the upper than in the lower extremity.

The fitting of artificial appliances is largely a matter of individual specialization. Stock legs and arms will not prove satisfactory, except those parts not involved in the actual fitting. Each patient's stump differs from the others and must be fitted accordingly.

The patient's occupation is an important factor in considering his permanent prosthesis. This is especially true in arm amputations where the prosthesis best suited for the patient's activities must be the first consideration. This makes artificial limb construction a highly specialized oc-

[1]Little, E. Muirhead: Brit. Med. Jour., 2, 550, Oct. 27, 1917.

cupation, which is becoming more intricate as the cinematiplastic amputations develop.

Temporary or Provisional Arms and Legs.—The desirability of early fitting of an amputation with an artificial limb is strongly emphasized. This was one of the lessons learned in the World War. In the past, authorities have advocated a delay of six to twelve months in artificial limb fitting to permit shrinkage and atrophy of stump tissues. Such teaching must be condemned, and the importance of fitting limbs as soon as healing will permit, substituted.

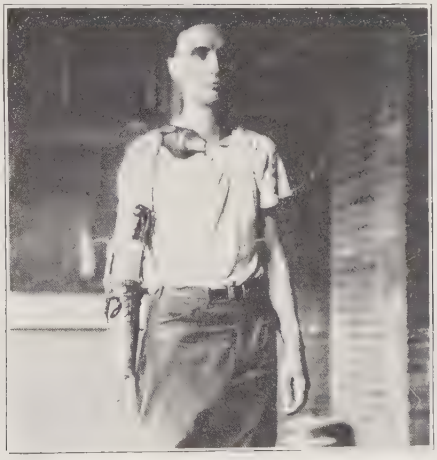
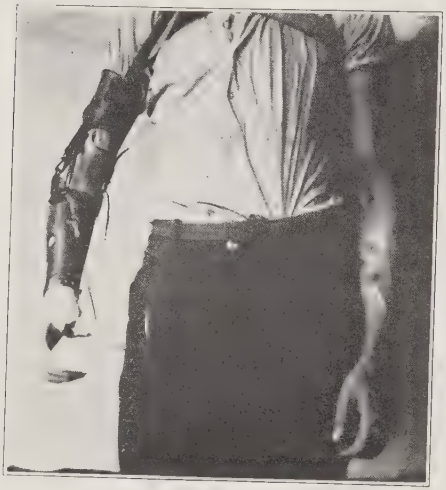


Fig. 71.—Provisional artificial arm with a leather socket.

In some cases it may not be necessary to have complete healing before fitting a temporary appliance to be worn at short intervals. In the upper extremity provisional arms (Figs. 71 and 72) are probably not so important as are provisional legs in the lower, but it is wise in most cases to fit temporary arms to early improve the muscle development, maintain function of the joints and train the patient to limb wearing before he grows one-handed. In the lower extremity a temporary limb should be fitted in practically all cases as soon as the wound is healed and the tissues will bear slight pressure. This will early accustom the amputé



A.

B.

C.

Fig. 72.—Type of temporary arm furnished the soldier by the Government. (A) Fitted with wooden hand the thumb of which is moved by an attached cord. (B) Able to grasp a mandolin pick with the wooden hand. (C) Can also lift his hat.

to wear a limb and thus avoid the crutch habit, accustom the stump to pressure, produce necessary shrinkage rapidly, develop the muscles that are to be used to walk and maintain function of the joints.

The shrinkage and atrophy of a lower limb stump is very important from the standpoint of fitting. It is amazing how much some stumps will shrink. This precludes the advisability of an early fitting with a permanent limb, because in a few weeks or months the stump will become too shrunken to fit.

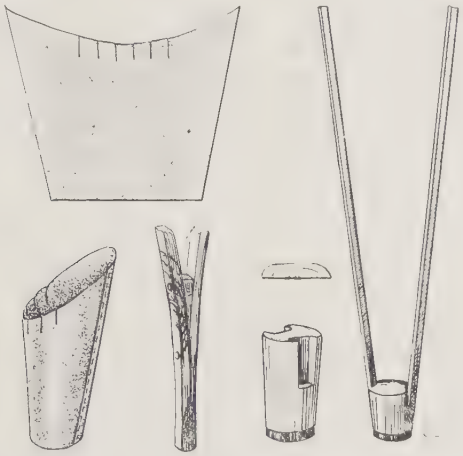


Fig. 73.—Materials for constructing plaster peg leg or pylon. Ordinary saddle felt is used to protect the stump. (Redrawn from Military Surgeon.)

Shrinkage of a stump may be more slowly accomplished by snug bandaging with a flannel or elastic bandage alternating with massage, and bathing. A leather "shrinker" is often supplied by limb manufacturers, which has some value. No method of shrinkage is as satisfactory as early fitting.

One of the most practical types of temporary stump sockets is constructed from plaster of Paris. This has the objection of being somewhat heavy, but it is inexpensive and easily changed as the stump shrinks. In very hot weather it may be coated with shellac to avoid crumbling

from perspiration. The plaster sockets for the thigh stumps may be built around a frame or peg as shown in the illustrations (Figs. 73, 74, 75, 76, and 77). A very practical method is to use a crutch with the upper portion cut away (Fig. 78). This is strong, light, easy to obtain and requires the minimum of carpenter work. In the leg, the construction is somewhat more difficult, but a simple peg with long

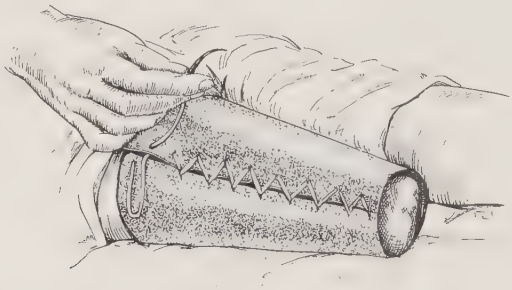


Fig. 74.—Method of applying felt to stump in making temporary pylon. (Redrawn from Military Surgeon.)

Fig. 75.—Applying plaster socket over felt. Felt is held firmly against perineum and ischium by a strap. The shoulder straps before and behind are incorporated in the plaster. (Redrawn from Military Surgeon.)

shoulder straps may be used. A better fitting may be had if the plaster socket is built between side irons with a hinge at the knee and a wooden foot or simple peg (Fig. 79). In the World War inexpensive types of provisional limbs similar in construction to permanent limbs were furnished in quantity (Figs. 80 and 81). These prostheses, while excellent, are not so practical for use in civil life because they are usually not available.

Another type of peg leg may be made of fiber, by making a cone-shaped socket held by rivets. This has been called in England the "megaphone leg" (Fig. 82). The upper end of the cone is shaped and padded to fit the stump and

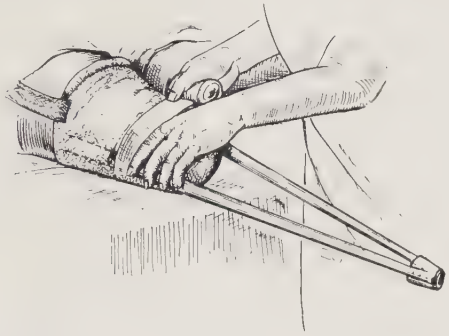


Fig. 76.—Incorporating the frame in the plaster socket. (Redrawn from Military Surgeon.)

Fig. 77.—The completed peg leg or pylon. (Redrawn from Military Surgeon.)

into the lower end is inserted a block of wood which rests on the ground.

The provisional appliances noted above are in no way superior to fitting with a permanent limb with later change of socket after shrinkage of the stump. To make a new

socket for a permanent limb entails more expense but has to commend it the outstanding feature that the patient learns from the beginning to handle the jointed limb which he is to wear in the future and the muscles necessary for its use are properly trained and developed. During the process of shrinkage, stump socks may be added until the stump in three to six months has reached a practically

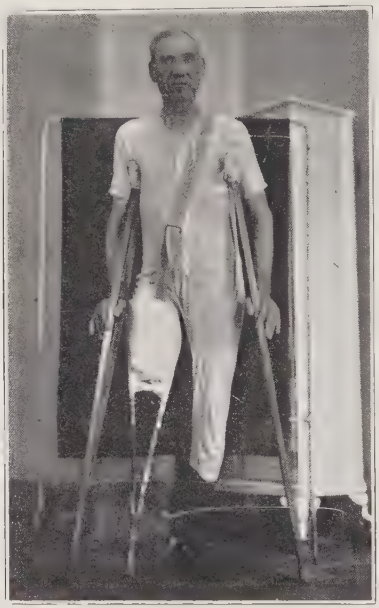


Fig. 78.—A plaster pylon made with the lower portion of a crutch. This is quite simply and easily constructed.

stationary size. When the second fitting is made, the patient will have fairly well mastered the handling of the limb, and several months' delay in its use will have been avoided.

In very high thigh amputations or hip disarticulations, the value of the provisional leg is more doubtful, but it should be fitted, if possible, to determine the patient's ability to wear an artificial appliance. A permanent limb

may be fitted in such cases and the socket changed as indicated. Such sockets are usually made of leather.

Bearing points in limb fitting should receive careful consideration. Limbs may be fitted with: (1) end bearing, (2) combined end and lateral bearing, and (3) complete

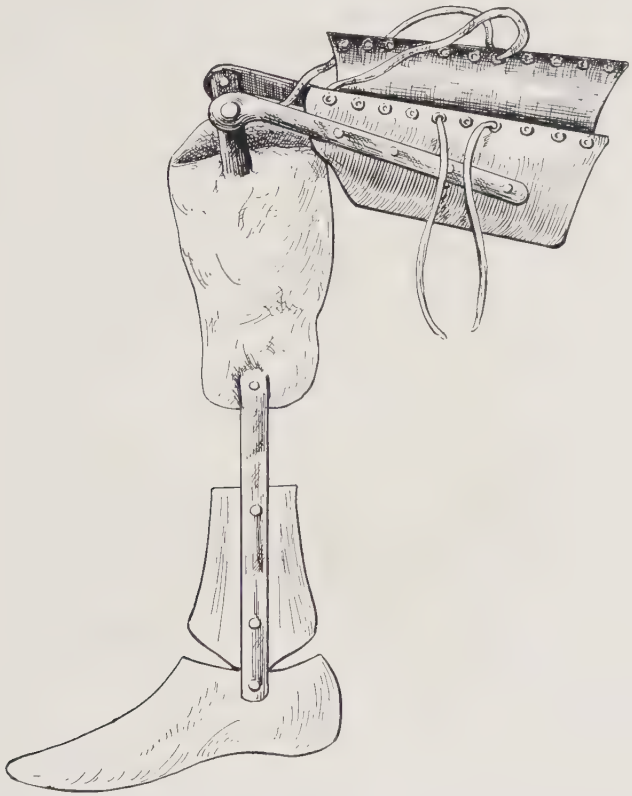


Fig. 79.—Type of provisional artificial limb for below knee amputation. The socket made of plaster of Paris incorporates the upper portion of the lateral steel bars below the hinged knee joint.

lateral or bony prominence bearing (Figs. 83 and 84). End bearing is to be desired, but not often attained, except in the Syme and Gritti-Stokes amputations. The average artificial limb fitter gives little attention to end bearing. When possible, the stump should be trained for such bearing by gradually increasing pressure on the bone end soon after

Fig. 80.—Types of provisional artificial limbs used in the World War. The amputated were fitted with these limbs to be worn until their stumps were in condition for permanent fitting. The fiber or Trautmann and the wood or "Liberty" legs are here shown.

Fig. 81.—Double leg amputation as shown in Fig. 15, fitted with temporary fiber limbs.

healing. Partial end bearing may be accomplished by soft felt pads properly placed in the stump socket. Lateral bearing, the usual type, takes the pressure in the leg over the tuberosities of the tibia and the patellar tendon. Care

Fig. 82.—"Megaphone legs" for leg and thigh amputations. They are constructed of fiber rolled into a cone and held together with rivets. Blocks of wood are attached for weight bearing. These cheaply constructed pegs are used as temporary prostheses. (Johnston.)

should be used not to permit pressure on the prominent fibular head, to avoid tenderness and ulceration. In the thigh, the bearing is almost entirely on the ischium (Figs. 85 and 86). The amputé sits in the socket and the stump

is used as a lever. There is, in properly fitting sockets of both the leg and thigh, some bearing on the surface of the stump, which is sometimes spoken of as cone bearing.

Training an amputé in the use of an artificial limb is an individual problem in civil life (Fig. 87). In time of war, training class may be formed and graduated, systematic exercises of stumps given, both with and without artificial limbs. Nature never provided a human being with tissues suitable for artificial limb-wearing without some instruction. Unless proper guidance is given in the most efficient

Fig. 83.—Temporary limb fitted to a Gritti-Stokes amputation. The thigh socket is made of leather and is complete end bearing.

use of an artificial prosthesis, the patient is apt to become discouraged and never wear a limb. An explanation of weight-bearing, first steps in walking, manipulation of an arm or hand, should all be repeatedly taught and demonstrated to the early wearer of a prosthesis. Faulty fitting and lack of instruction cause many of the amputated to spend their lives with crutches.

Artificial Prosthesis for Hand Amputations. -To replace an amputated hand a complete artificial hand may be worn or any one of a great many hooks, clamps or other devices

adapted to the occupation of the wearer (Figs. 88 and 89). Many hands are constructed and worn for the sake of appearance only. The most elaborate hands yet constructed, cannot in any way simulate the intricate function of the human hand. Their motions are usually limited to flexion and extension of the fingers which furnish grasping and holding. Aside from hands activated by plastic motors the

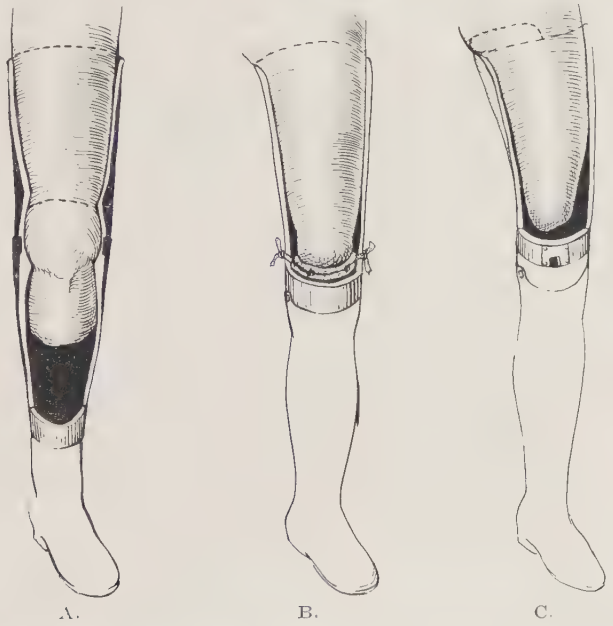


Fig. 84.—(A) Lateral weight bearing stump. (B) Partial end bearing stump. (C) Weight is here borne by the ischium.

Carnes is the best American made hand on the market (Figs. 90 and 91).

Most artificial arms are so constructed that the hand may be removed and a hook or other tool substituted as required. Appliances that may be adaptable to the workman's uses are many (Fig. 92). The vine-dresser's hook, postman's hand, horticulturist's hand, packer's hand, plumber's hand, leather cutter's hand, grip for hammer, chuck for holding file or other tool, tram-driver's appliance and others are

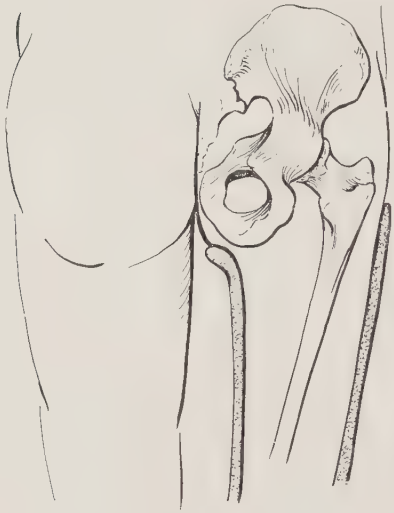


Fig. 85.—Shows proper relation between artificial limb socket and ischium. Weight bearing should be upon the ischium and not on the perineum.

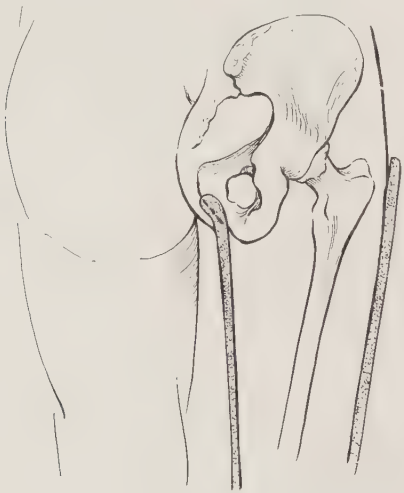


Fig. 86.—Shows a common faulty fitting of thigh socket. The ischium has slipped inside the socket permitting pressure upon the perineum.

described by Broca and Ducroquet (Fig. 93). Specially constructed instruments to promote the amputé's comfort and efficiency are many (Fig. 94). Such instruments and tools are often the product of intelligent and industrious individuals who do not permit the loss of a leg or arm to check their progress.

When both hands are lost the problem is truly great. Such amputé's have much difficulty in attending to the ordinary duties of life and often require a constant personal attendant. Earning a livelihood is usually out of the ques-

Fig. 87.—An apparatus made of metal tubing fitted with small rollers to aid patients in learning to walk who have had both lower extremities amputated.

tion, although a few may be able to follow some gainful occupation. The use of the teeth and feet in these cases may reach a high state of perfection after long years of practice. In some cases, the usefulness of a forearm stump, which from training has acquired considerable cutaneous sensibility, may be superior to an artificial appliance.

Artificial Limbs for Forearm Amputations.—In forearm amputations, artificial arms purely for the purpose of masking deformity, for work, or arms designed to fulfill both

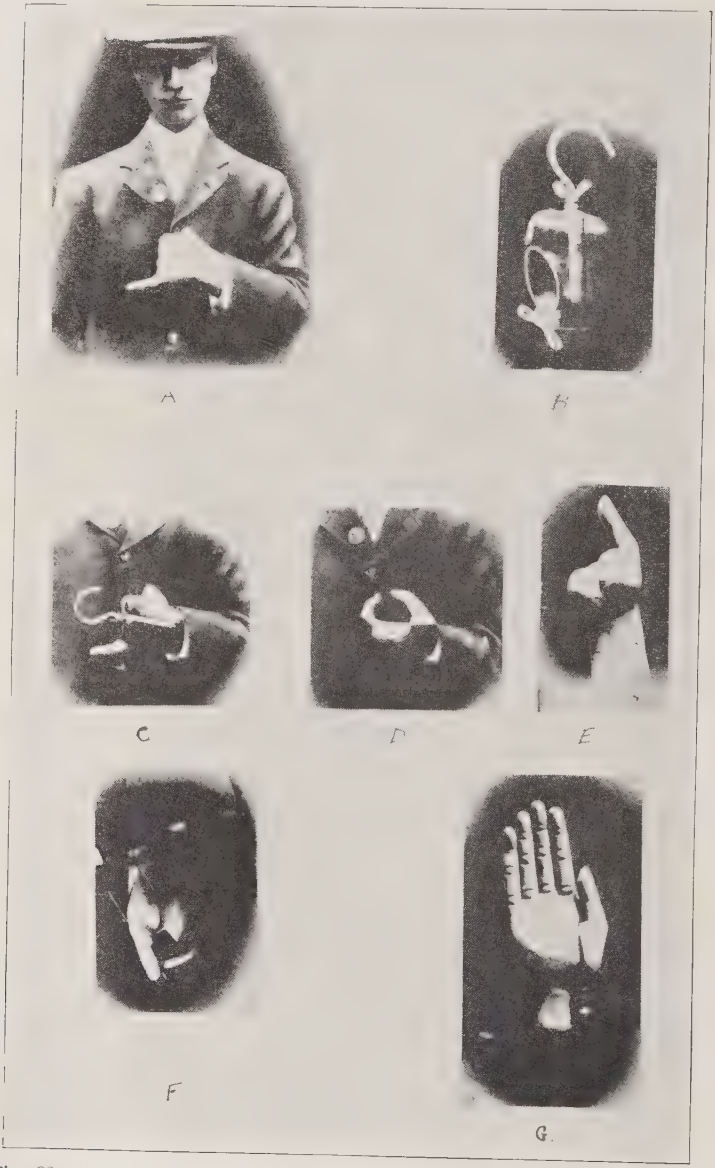


Fig. 88.—(A) Loss of all the digits except the little finger. (B) The working prosthesis for the same. (C) Shows the prosthesis in use. The hook can be removed and other appliances attached. (D) A wooden thumb may be attached which gives grasping power to the little finger. (E) Loss of all digits except the thumb. (F) The same fitted with an opposition appliance enabling the patient to grasp objects. (G) Ornamental fingers to be worn in a glove. The fingers are fully articulated and the index finger may be opposed to the thumb to grasp small objects. (After Little.)

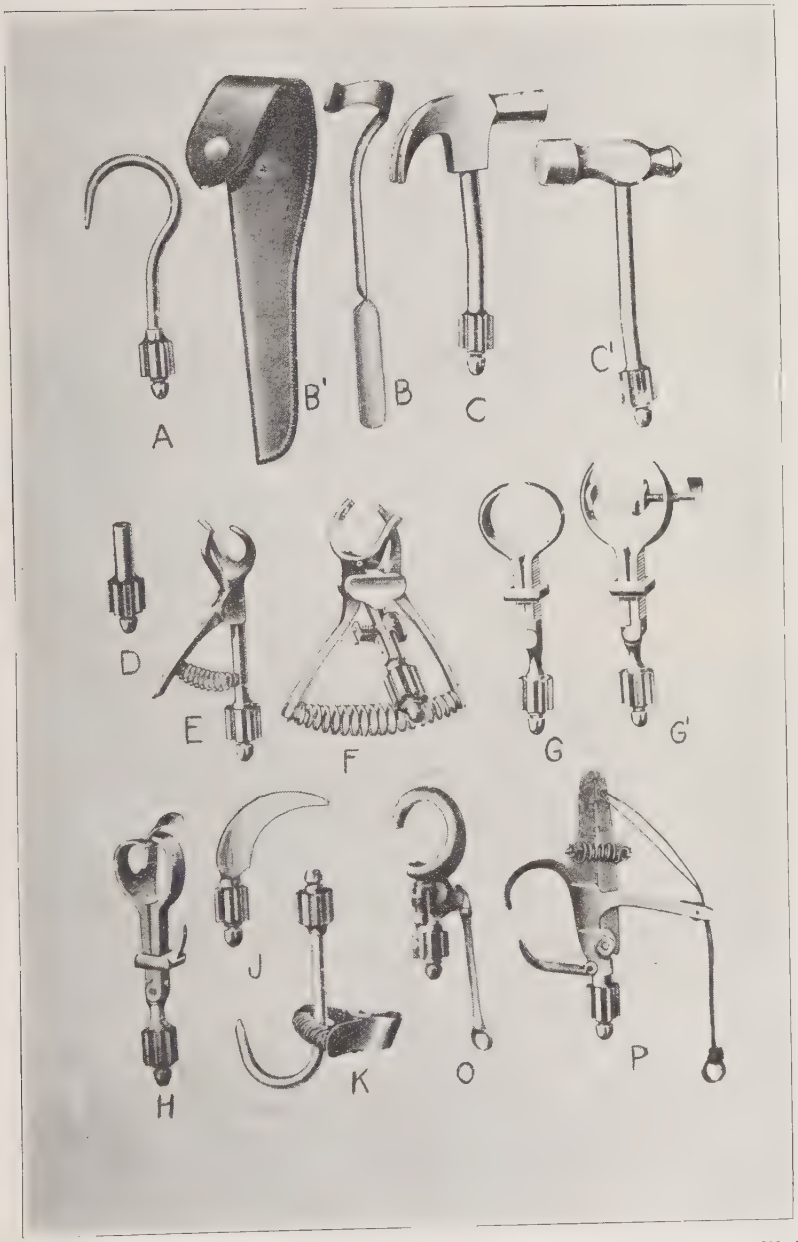
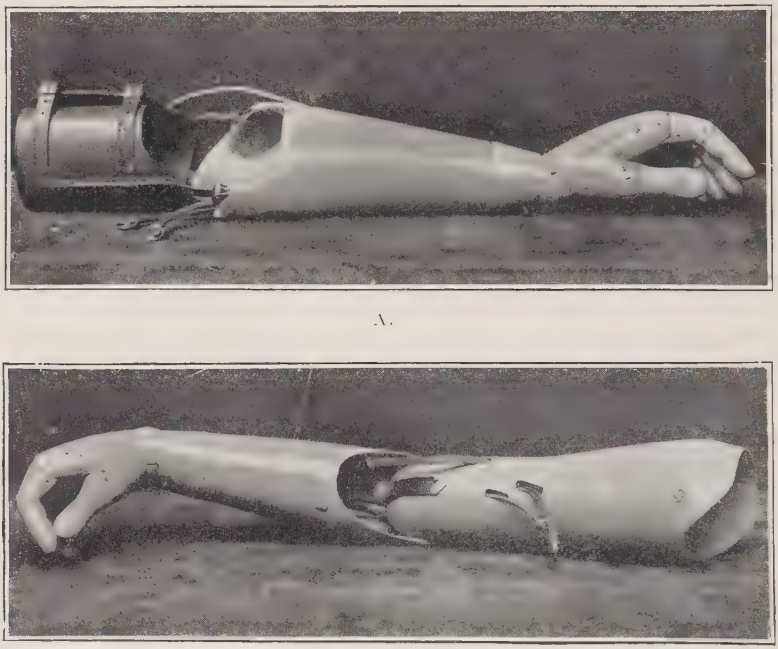


Fig. 89.—Appliances made by McKay Artificial Limb Company. (A) Plain hook. (B) Special table knife. B' Leather pocket sheath for table knife. (C and C') Claw and riveting hammers. (D) File holder with hollow threaded center. (E) Brace and chisel grip. (F) Shovel grip. (G and G') Spade and wheelbarrow grips. (H) Saw grip. (J) Hooked knife for leather work and boot repairing. (K) Painter's hook. (O) Mechanical spring split hook for general use. (P) Universal pliers with attached adjustable hook. (Little.)

purposes may be used. Forearm sockets may be made of wood, fibre, leather or metal depending upon the manufacturer and the desire of the amputé (Fig. 95). The leather socket is often laced and is therefore adjustable and, in many cases, more desirable. It is usually wise to have the arm so constructed that the hand may be removed and any type of appliance required by the worker substituted.



A.

B.

Fig. 90.—(A) The Carnes arm for forearm amputation. (B) The Carnes arm for arm amputation.

Artificial Limbs for Arm and Shoulder Disarticulations.—In amputations through the arm, a hinge is required at the elbow. Some arms are so constructed that the forearm may be removed and a hook attached at the elbow. This type is valuable for workmen whose duties require heavy lifting. Motion at the elbow is usually controlled by straps through shoulder motions or the elbow may be locked in any position

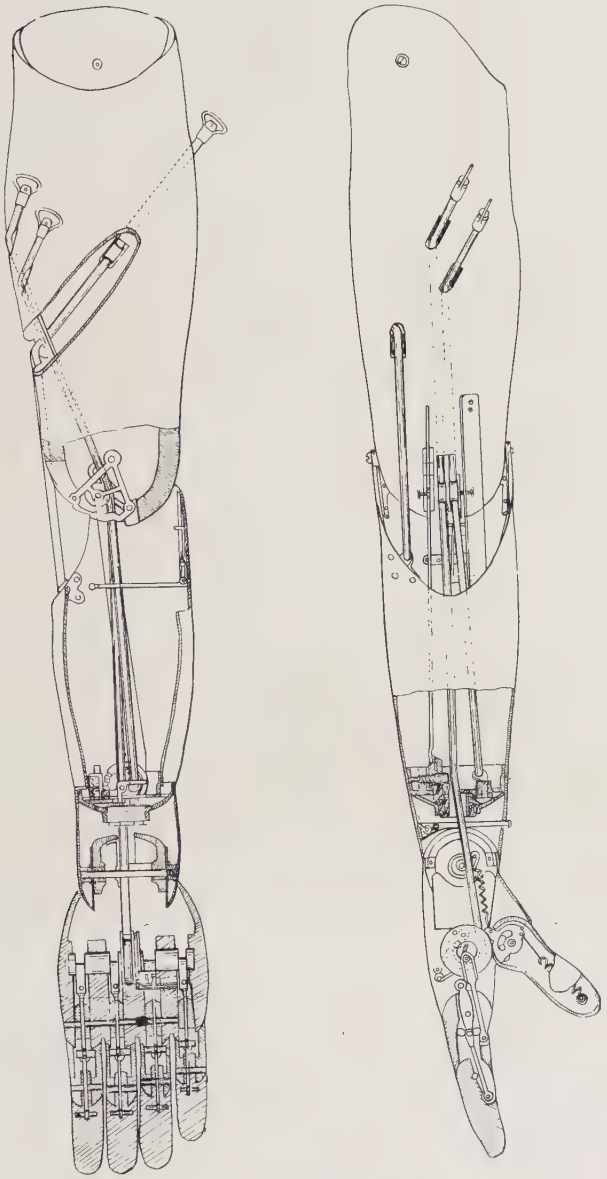


Fig. 91.—Drawings illustrating the internal mechanism of the Carnes artificial arm.

desired. When the arm is not in use it swings at the side with the ratchet loose.

Short arm stumps and shoulder disarticulations really fall in the same class as far as function is concerned. It is

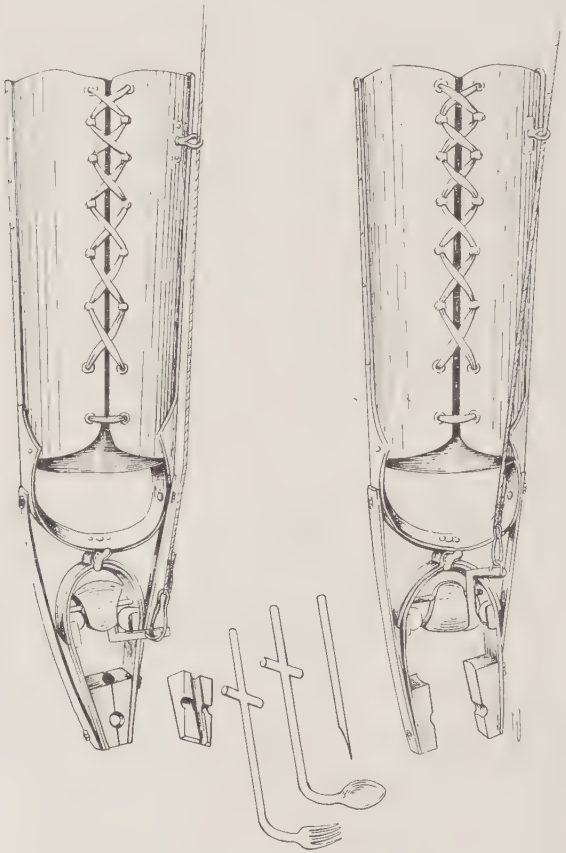


Fig. 92.—Brunet's grip. Jaws are opened by a rotating cylinder attached to a cord extending from the sound shoulder. (Redrawn from Broca and Ducroquet.)

difficult to obtain function of any nature beyond such simple usage as steadying a piece of paper while writing, carrying a parcel, light lifting and slight gripping power with a spring thumb or a thumb controlled by a shoulder strap. As a rule, some difficulty is experienced in convincing

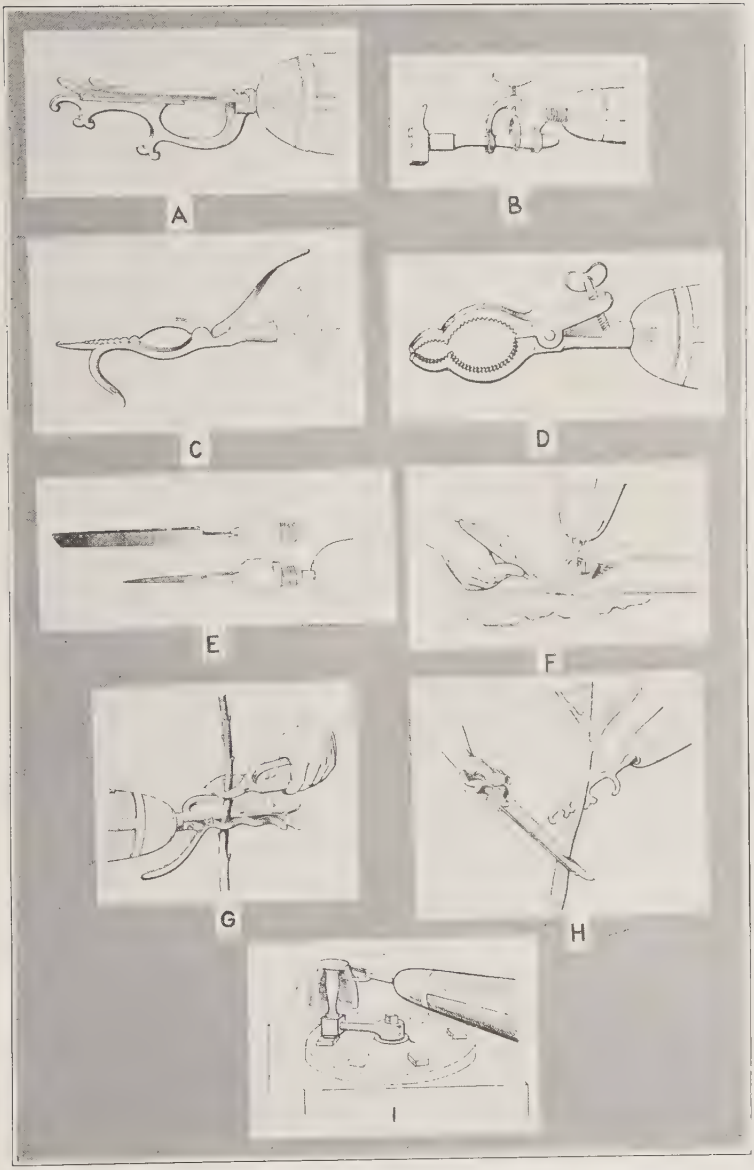


Fig. 93.—Appliances for workmen that may be attached to an artificial arm. (A) Postman's hand. (B) Grip for hammer or saw. (C) Packer's hand. (D) Plumber's hand. (E) Chuck for file or other similar tool. (F) Leather cutter's hand. (G) Horticulturist's hand with method of holding a branch. (H) Vine dresser's hook. (I) Tram driver's or chaffeur's bell. (Broca and Ducroquet.)

patients with shoulder disarticulations of the advisability of wearing an arm, they usually prefer an empty sleeve.

Artificial Prostheses for Foot Amputation.—Foot amputations are very difficult to fit when the amputation is proximal to the metatarsals. A block of wood or cork with sponge-rubber cushion behind may be used to fill out the shoe (Fig. 96). Because of contractions that occur in amputations through the tarsals an artificial limb fitter will almost universally prefer a mid-leg amputation for efficient fitting (Fig. 97). It is therefore wise not to amputate

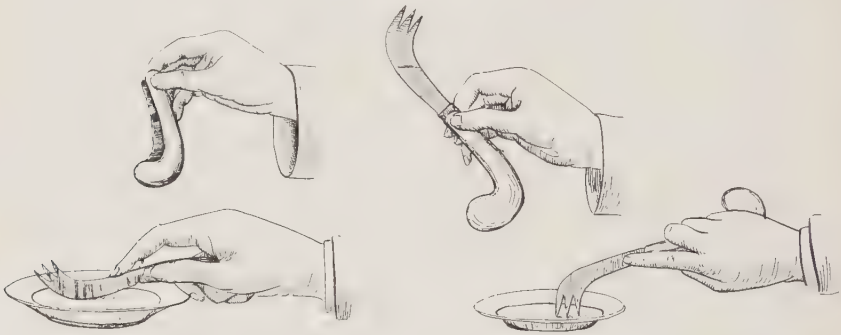


Fig. 94.—The Marks combination knife and fork. This opens with a spring lock. It can be carried in the pocket like an ordinary penknife.

through the tarsals, but substitute a Syme or mid-leg amputation.

Artificial Limbs for Leg Amputations.—Legs are made of wood, fiber or metal. In America, the willow-wood leg and socket is the most used, although the fiber is preferred by some (Figs. 98 and 99). In England duralumin, an alloy of aluminum has proved useful. Amputations through the leg are most easily fitted. They may have end bearing, partial end bearing or lateral bearing depending upon the location and type of stump. If the condition of the stump will permit, it should be trained to end bearing and fitted with such a limb. In rare instances, it may be wise to

fit a knee-bearing peg, with knee joint, but this type of leg is not to be recommended. The "elephant boot" (Fig. 100) may be used by workmen having Syme or Pirogoff amputa-

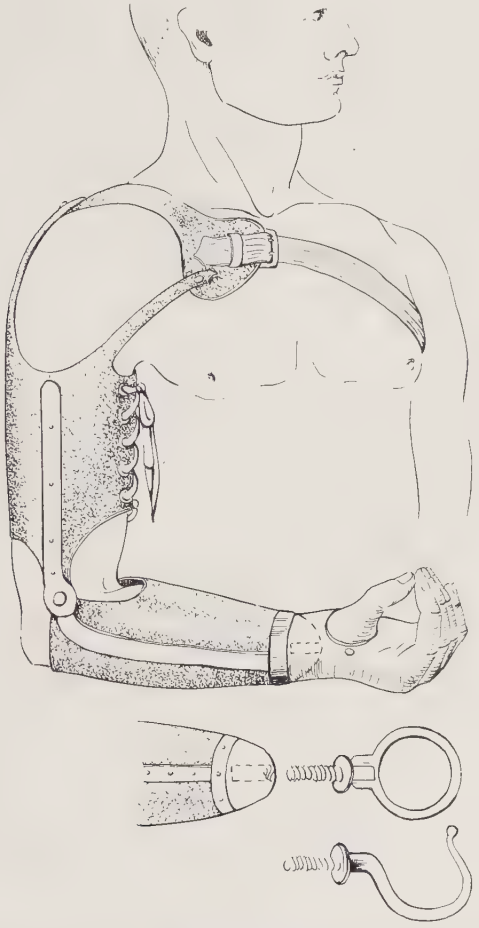


Fig. 95.—Artificial arm for forearm amputation fitted with detachable hand, ring and hook. (Redrawn from Broca and Ducroquet.)

tions as more convenient and durable than a jointed limb. Some manufacturers use what is called a slip socket (Fig. 101), which fits within the main socket and moves up and down with the motions of the leg or thigh.

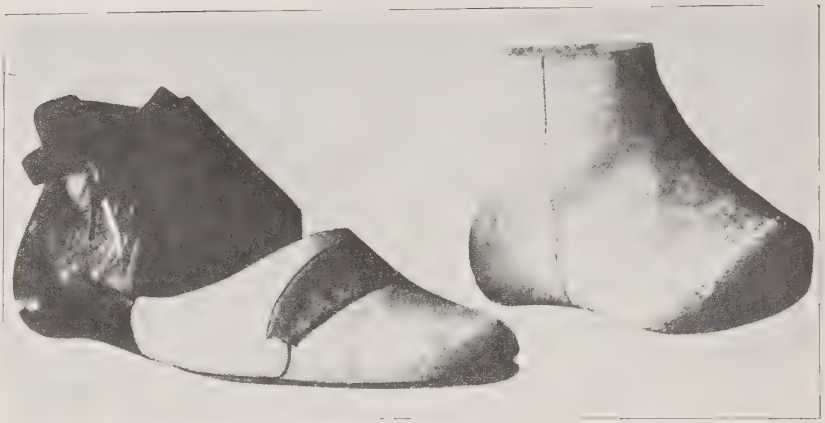


Fig. 96.—Prosthesis for Chopart's amputation. It is constructed with a stiff leather sole piece and soft leather laced anklet. The missing part of the foot is replaced by a toe of wood with a hinged toe-joint. The portion next to the stump is padded with sponge rubber. (Little.)

Fig. 97.—A Chopart amputation with contracture of the calf muscles. It is fitted with a partial foot and stiff metal piece extending upward in front of leg. This is a very difficult amputation to fit.

Artificial Limbs for Thigh Amputations.—Like the leg, the thigh sockets may be constructed of wood, fiber or metal. The French have used leather reinforced with steel with apparent satisfaction. On the whole, the wood seems to give the greatest and most universal satisfaction.

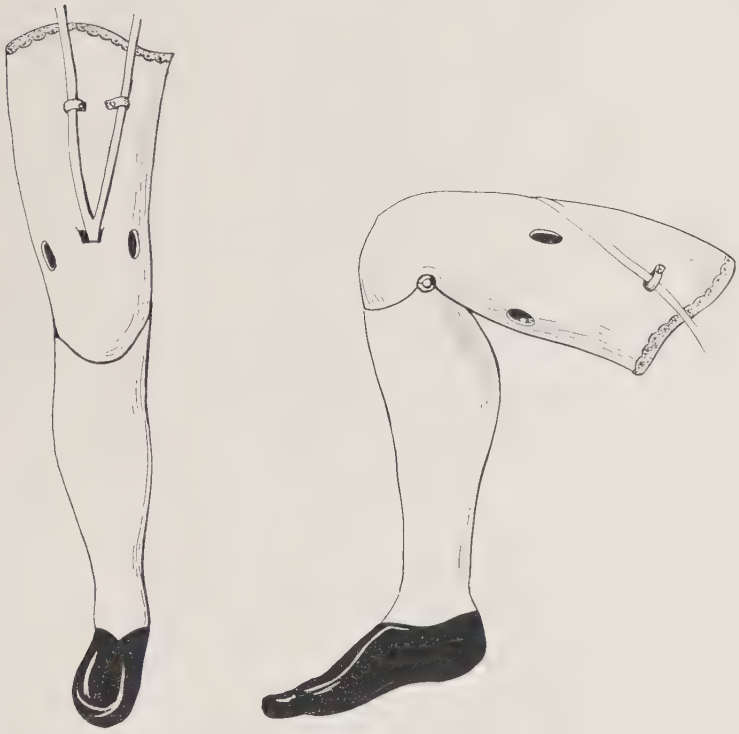


Fig. 98.—Artificial limb made of willow wood with sponge rubber foot. There is also a ball bearing ankle joint. (Rowley & Co.)

Fig. 99.—(A) Artificial limb for Syme and Chopart amputations. (B) Artificial limb for below knee amputation made of willow wood and fitted with rubber foot. (Rowley and Co.) (C) Canadian type of artificial limb for Syme amputation. (Col. C. L. Starr.)

Fig. 100.—The "elephant boot." This is analogous to the peg leg. It is sometimes used for Syme or Pirogoff amputation.

Fig. 101.—Artificial limb with slip-socket for below knee amputation. (Winkley Artificial Limb Co.)

Hanger and Company have built a light metal limb with a wooden socket that may prove very serviceable (Fig. 102). Short thigh and hip amputations require the addition of a pelvic band to stabilize the limb. A special type of limb,

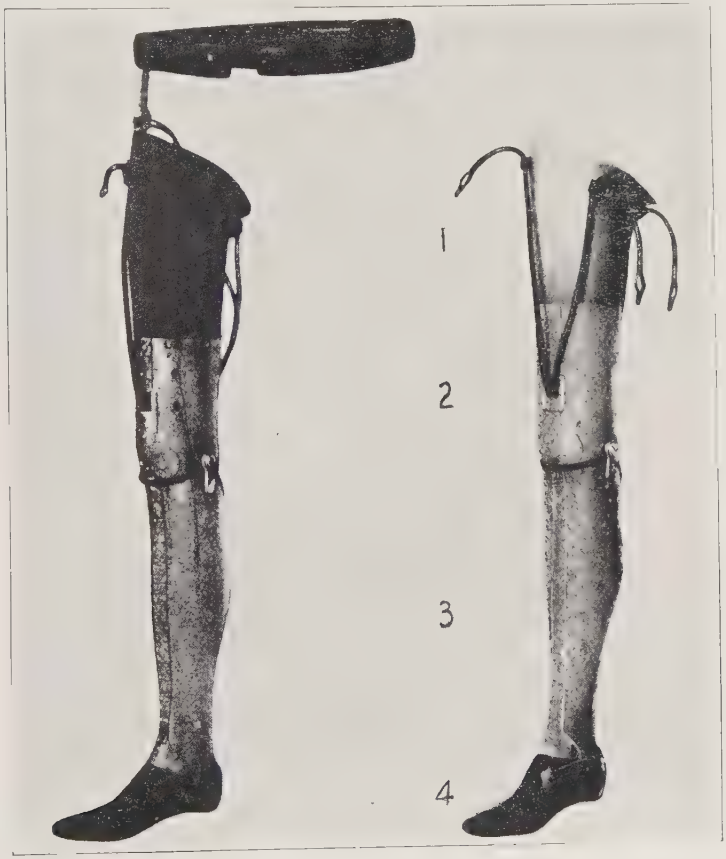
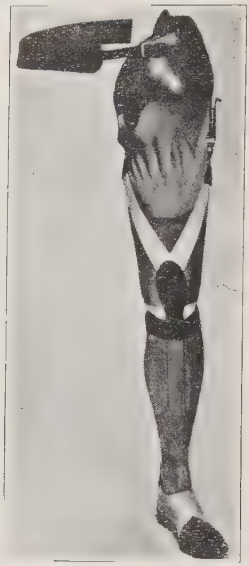


Fig. 102.—Light metal limbs made by Hanger and Company. They are constructed with (1) wooden socket, (2) metal thigh piece, (3) metal shin piece and (4) wooden foot. (Little.)

called the "tilting table" (Fig. 103) has been designed for amputations through the neck of the femur and hip disarticulations. This is equipped with lock joints so that the entire limb can be swung from the body and when sitting, the joints can be unlocked to permit flexion.



A.

B.

C.

Fig. 103.—Tilting table artificial limb for hip amputations. (A) Limb is fitted with a pelvic band and stop to lock it in extension for standing or walking. (B) Patient wearing limb in sitting position. (C) Patient standing. (Huggins.)

A.

B.

C.

Fig. 104.—(A) Double thigh amputation at junction of upper and middle thirds. (B) The same patient fitted with short plaster pylons learning his first steps. (C) Fitted with full length limbs.

A different problem exists in the fitting of double amputations, especially through both thighs (Fig. 104). It is usually advisable to reduce the former height of the patient one and one-half to two inches, thus making locomotion and balance easier. Workmen with short thigh amputations may wear short peg legs which enable them to more easily maintain balance.

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